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FIRE CONTROL NOTES

A PERIODICAL DEVOTED
TO THE TECHNIQUE OF
FOREST FIRE CONTROL

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PROCUREMENT SECTION
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FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.

FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

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Forest Service, Washington, D. C.

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NOTE: The April 1959 Fire Control Notes will emphasize Fire Control Training. Special assignments of certain articles have been made but the editor would welcome additional items on this general subject. These must reach the Washington office by January 15.

EQUIPMENT DEVELOPMENT AND FIRE RESEARCH¹

MERLE S. LOWDEN

Director, Division of Fire Control, U. S. Forest Service

People look at equipment development in a variety of ways. Some think of it as a mechanic with a monkey wrench tinkering with a machine that never works when you most want it. Others think of it as scientific research with complicated chemicals, formulas, and machines. Somewhere between these two extremes lies equipment development as we are trying to approach it in the Forest Service and as I see it in relation to the fire control job. Surely it has a very close tie to research, but there is a difference. Working as a team we must depend upon research to find the fundamental facts and to determine relationships between cause and effect.

Equipment development takes the results of research and tries to find a way to do it with machines. Let me take an example to illustrate this point. We are hearing a lot these days about aerial attack on fires with fire retardants. Research, development, and trial use were combined in the Operation Firestop project several years ago in California. One of the basic research studies at that time was to try many chemicals and compounds to test their value as wildfire suppressants and retardants. The most successful found by those tests was sodium calcium borate which is now becoming widely used. Also a part of the Firestop operation was the study of cascading water from an airplane from various heights to determine distribution and effectiveness on the ground. It was a logical step to mix water with the successful retardant and to apply the mixture from the air.

Actually doing the job, of course, is much more complicated than thinking about it. This took a great deal of analytical calculation and study, adventuresome imagination on the part of the field men in testing, good engineering in figuring the types of gates and openings to use for tanks, and the combining of many skills. The operation, while successful, is still in its infancy. However, this year there are 70 planes in this country available and equipped to attack fires from the air. Progress from an idea to a successful operation required a continuously working team of research, equipment development, and the actual users (or fire fighting organizations).

Most of our equipment development requires this same type of teamwork. Somebody must take an idea or research result and build or adapt a machine to it that is successful in field operation.

¹Taken from a paper presented at the Region 9 Fire Committee Meeting, Grand Rapids, Minn., June 12, 1958.

In its application to the field there is another highly important task for research. This is in setting up procedures and methods for evaluation and in giving technical advice on the evaluation and analysis of results as they come from the tests.

There are many supplemental features or accompanying steps in equipment development. Often times we can get results by having industry do the job without any immediate cost to the Government. This we try to do as often as we can. In many cases after an article shows wide application with sufficient opportunity for profit in its manufacture, the development will be carried forward by some manufacturer. Field radios are a good example of this. The Forest Service did the early development work and made the first sets. They continued for a time to develop and make pilot models. Later manufacture of these models was contracted. As this business expanded to many agencies and small radios had widespread use, leading manufacturers began their own development program. At present the Forest Service mainly carries its needs to the manufacturers, checks and works with them in development, and tests results. Practically the entire job is done by private industry.

Another supplement to development is to take a product used for one purpose and adapt it to another. Through such trial use we may discover an article that fits our fire needs. A good example of this is the use of the railroad fusee for backfiring.

Equipment development frequently leads to standardization and ties in with specifications for manufacture. It is hard to separate these parts of the total job.

Another task that goes with development is getting people to use the new article. Regardless of how good a "mousetrap" we develop, it doesn't amount to much if nobody uses it. We have some glaring examples where we have spent much money and developed a fairly good product but have done a poor job of selling it for field use. Our fireline trenchers are somewhat in this status.

We have many methods of selling ideas. Written material, such as technical bulletins, progress reports, magazine articles, and handbooks, has its value. Demonstrations are a tested method and have been used a great deal by your group. "Chautauqua" tours are not as common but have been used with good success. Those developing trail-building equipment in the West have had outstanding success with demonstration tours. In the Forest Service we often use the free sample method; that is, we fully or partially finance from the Washington Office an early model. Regions or forests may be reluctant to spend their money on a new item, but once they try it and it is successful they are very willing to use their funds to buy more. It is always possible, of course, to issue orders to use new equipment but if this is necessary we have failed somewhere in the selling job.

I might say something about the Technical Equipment Board system in use in the Forest Service. We have a rather large board in the Washington Office appointed by the Chief and drawn from various units which have an interest in equipment development. Many of the regions have smaller but similar groups. Field units

make proposals through the regional boards in a prescribed manner. Field folks at all levels are encouraged to suggest projects to be included in the equipment development program.

Proposals are reviewed within each region and those which find favor are recommended to the Chief's office for further consideration. There they are reviewed by the functional division that has the greatest interest in the project. For fire equipment this would be in the Division of Fire Control. The functional division reviews and recommends projects for coordination by the equipment board. This board prevents overlapping or duplication and arranges joint financing where several functions are interested. It brings together many interests and often a new machine or idea is found to have many applications in different forestry functions. Some modification may make a machine useful for many jobs. Each functional division thus can plan its program, and carry through on the introduction to field units. The equipment development program for the Forest Service is coordinated by the Technical Equipment Board and the action plan issued for each fiscal year.

Actual development work is done in many locations throughout the country but our main efforts have been concentrated in a few equipment centers. At Arcadia, Calif., we are concentrating on pumps and tankers, small mechanized handtools, helicopter accessories, aerial tankers, spark arrestors, and machines for testing other machines and apparatus. At Missoula, Mont., work connected with smokejumping and air cargo transportation is underway. This includes new and different parachutes, cargo packaging, protective clothing, letdown equipment, and other aerial items. We have also done most of the fireline trencher work there. A development center somewhere east of the Mississippi River has been under consideration for some time.

Radio and electronic work is now concentrated at the Beltsville Radio Laboratory outside of Washington and we have recently strengthened and broadened the work there.

Some projects are done at the experiment stations and in the regions. Methods of air cargo delivery and water transportation by plane have been worked on for several years by the Superior Forest at Ely. The Forest Service for many years carried on joint work with the State of Michigan at Roscommon. After a lapse of a few years we again have an agreement and are working with them on development of a sandthrowing machine.

Equipment development work in fire control may be classed in various ways. I like to think of it as falling into two main groups. The first is that in which known and tried items are improved or further developed. Many of these are continuing jobs such as those in our smokejumper project where we are continually improving parachutes, rigging, protective clothes, and similar items. The second is the pioneer type in which we explore new fields and new ideas, such as large-tire carriers and fire suppression rockets.

FIRELINE TRENCHER ATTACHMENT FOR POWER SAWS

RAYMOND M. WEST, *Anaconda Forest Protection Service*, and
ROBERT W. STEELE, *School of Forestry, Montana State University*

The power saw trencher is a lightweight combination trenching and cutting machine for fireline construction. It consists of two spiral augers mounted on a shaft at the end of a standard chain saw blade (fig. 1). The teeth of the cutting chain turn the augers by means of a sprocket in the center of the shaft.

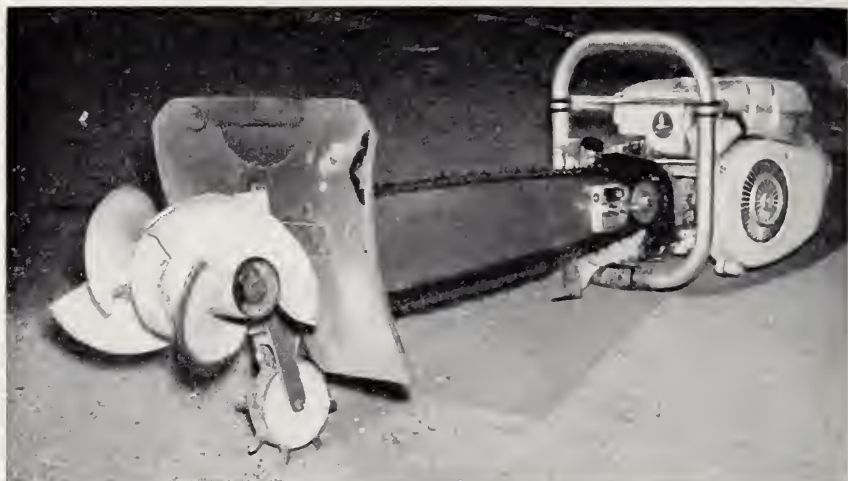


FIGURE 1.—Powered lightweight trencher. Note two-way spiral augers and the small support wheel.

The two-way spiral augers are 7 inches in diameter. Each is 6 inches wide so that a trench a foot wide can be constructed (fig. 2). The augers are made of abrasion resistant steel and are keyed to a shaft which is mounted in bearings on the sides of the blade.

Power from the saw motor is supplied to turn the augers through the cutting chain as the chain moves along the blade and engages the sprocket. The rotating augers throw dirt to both sides, making a clean trench.

In operation, the machine is held at a steep angle while resting on a small support wheel (fig. 1) mounted directly below the blade. The depth of trench can be varied by raising or lowering the handle of the power saw motor to engage the rotating augers in the soil. A guard protects the operator from flying dirt and stones. The suggested method of use is with a 3-man crew, one with the trencher, one with a pulaski for heavy cutting and digging, and one with a shovel for line cleanup.



FIGURE 2.—A foot-wide trench can be cut.

The machine digs readily through sod and duff to mineral soil. It throws needles and other forest litter out of the trench, and is easily moved along the fireline. It can be operated both forward and backward on slopes or level ground. When necessary to cut a windfall or snag during the construction of a fireline, the machine is used as a conventional power saw, there being sufficient length of cutting blade back of the protective guard (fig. 3).

The advantages of this combination cutting and digging power tool are—

It is small and light, and can be transported anywhere about a fire.

It can be packaged for aerial delivery.

The unit complete with blade, chain, and augers weighs approximately 10 pounds.



FIGURE 3.—Machine used as a conventional power saw on a windfall.

It can be used on most standard chain saw motors and is easily attached by simply removing the original blade and chain.

No special training is needed to operate it.

It can produce an effective fire trench rapidly by mechanical means.

TRACTOR HEADLIGHTS

A. B. EVERTS

*Equipment Engineer, Division of Fire Control, Region 6,
U. S. Forest Service*

Region 6 was asked to develop a lighting outfit for tractors. This outfit was to fit on any tractor rented for fireline construction. Field sampling of opinion indicated that there should be three lights, two forward and one backup, and that the direction of each beam be adjustable.



FIGURE 1.—Universal clamp will fit either round or square canopy supports. Clamp is lined with brakeshoe material to provide a sure grip.

The first problem to solve was how and where the lights should be attached to the tractor. Most logging tractors are equipped with canopies. In many States the law requires that they be so equipped. These canopies, however, are not all of the same design. Some of the supports are round, and some of them are square. The clamp designed will fit either type (fig. 1).

Some tractors are equipped with batteries. These may be either 6 or 12 volt. The kit, therefore, contains both 6- and 12-volt light bulbs. Alligator clip quick connectors provide a means of clamping the headlight wires to the wet battery. If the rented tractor has no battery, then 12 No. 2 dry cells can be used. These are connected in groups of 4 each.



FIGURE 2.—Complete tractor-lighting outfit.

The complete kit, developed to meet forest fire fighting needs (fig. 2), is now available commercially. The lights and clamps can be purchased separately where it is known that the tractor on which they will be used is battery equipped.

The standard contents for the kit are as follows:

- 3 Tractor lights with 15-foot twin wire cords equipped with positive and negative insulated quick clamps and 6-volt lamps.
- 3 Wire lens guards for lights.
- 3 Universal adjustable clamps for canopy stanchions.
- 2 Battery boxes with terminals, each to accommodate 12 No. 6 dry cell 1½-volt batteries.
- 6 Dry cell connector plates.
- 24 No. 6 1½-volt dry cell batteries.
- 3 Lamps, 6-volt G.E. No. 1021.
- 6 Lamps, 12-volt G.E. No. 1327.
- 20 feet of twin wire cord.
- 2 Rolls 4-inch insulated tape.
- 1 8-inch crescent wrench.
- 1 6-inch pliers.
- 1 6-inch screwdriver.
- 2 Spare wingnuts for clamps.
- 6 Spare washers for clamps.
- 6 Spare hex nuts for lamps.
- 6 Spare lockwashers for lamps.
- 3 Spare battery box wires.

The kit, complete without batteries, weighs 85 pounds. Its dimensions are 15 by 16 inches, 28 inches long. Further information can be obtained from the Division of Fire Control, U. S. Forest Service, 729 N. E. Oregon St., Portland 8, Oregon.

FAN PSYCHROMETER

ROBERT M. LOOMIS, *Forester, Columbia Forest Research Center,
Central States Forest Experiment Station, and*
VIRGIL STEPHENS, *Fire Control Officer, Missouri National Forests*

Battery-operated fan psychrometers have been widely used to measure relative humidity at fire-danger stations. With electricity now available at many stations, a unit using this current is practical. A fan psychrometer suitable for locations where 110- to 120-volt, 60-cycle alternating current is available was assembled

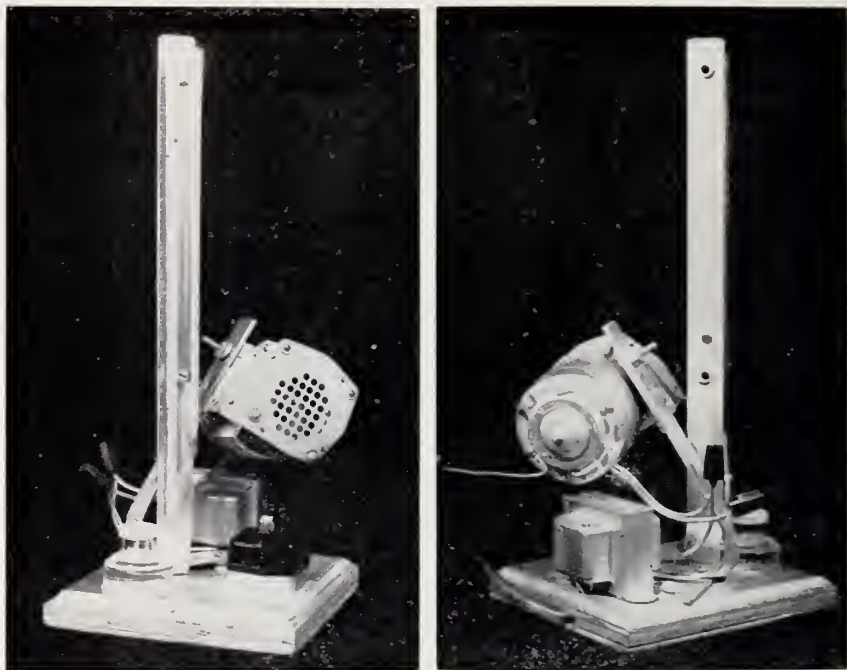


FIGURE 1.—Fan psychrometer: *Left*, Front view showing arrangement of wet and dry bulb thermometers, motor and fan, transformer, switch, and water container; *Right*, rear view showing assembly of motor and psychrometer, electrical wire connecting to 110-v. outlet entering base, cover for bottom of base, and ground wire from motor.

by Central States fire research personnel.¹ The 6,000-r. p. m. blower, 24-volt d. c. motor, and transformer were obtained as a unit through a radio-TV supplier for \$4.00.

This instrument is efficient and compact, and simple to operate. The high-speed blower draws air from the side away from the motor, eliminating the possibility of motor heat influencing the reading.

¹J. Allen Jackson, R-9 Training Officer, formerly Assistant Supervisor, Missouri National Forests, suggested this instrument.

The assembly shown in figure 1 is an example of a workable arrangement of the wood base, motor, transformer, blower-type fan, two strap-iron supports, switch, water bottle, and psychrometer. The wood base is $\frac{3}{4}$ by 7 by 7 inches, and is grooved on the bottom to carry the electrical wires. Holes are drilled to carry the wires through the base to the switch and transformer. Enclosing the electrical wires in the base is a piece of $\frac{1}{8}$ -inch Masonite attached to the bottom with countersunk flathead screws. A circular hole, $1\frac{7}{8}$ inches in diameter and $\frac{3}{8}$ inch deep, is cut into the base to hold the water container, which is an India ink bottle with plastic cover.

Two supports, one for the motor and one for the psychrometer, are bent from $\frac{1}{8}$ -inch by 1-inch strap iron, $10\frac{1}{2}$ and 17 inches long. Supports, transformer, and switch are held to the base with roundhead screws. The motor and psychrometer are attached to the supports with stove bolts. The psychrometer is kept from direct contact with the strap iron by tubular metal sleeves $\frac{1}{2}$ inch long. Blower and thermometers are arranged so that the air blows against the dry bulb first. For safety the motor is grounded with the wire from the rear of the motor.

This type of instrument is now in use on the Missouri National Forests and is proving satisfactory.



Inexpensive Scanning Stereoscope

In office stereoscopic delineation of types, photo measurements, or dot counts on aerial photographs, nothing is more aggravating than to be hampered by the legs of a pocket stereoscope.

Freedom of hand movement can be obtained by rigidly mounting a stereoscope to a bar from an upright at the proper focusing height. However, this method requires that the photos be moved beneath the stereoscope for complete stereoscopic coverage, which is rather unhandy.

Commercial scanning-type stereoscopes are excellent and eliminate both of these disadvantages. Most of them, however, are too expensive for the average person engaged in photointerpretation.

A practical yet inexpensive scanner can readily be made by attaching a common magnifying stereoscope to a storm sash friction-type adjuster. The adjuster is screw-fastened to a short length of 2" x 2". The 2" x 2", in turn, is attached with screws to the left edge of a plywood base on which the photographs are placed. This viewing surface can be tilted toward the photointerpreter by raising the back edge to the desired height with legs or a wooden strip.

The friction disks at the three hinge points of the adjuster eliminate wobble but allow free roving of the stereoscope in a horizontal plane to any desired stereoscopic position over the aerial photographs. Smoother movement of the arms is accomplished by lubricating each joint and adjusting the locknuts. A hacksaw is used to notch the end normally fastened to the sash before bolting the stereoscope to it. One stereoscope in use has the standard 2X lenses mounted with an interpupillary distance of 63 mm. in an eyepiece made of $\frac{1}{4}$ " hardboard.

Certainly a more refined unit can be made by variations of the above. However, the point is that a stereoscope can be successfully adapted for scanning for about \$1.00—PAUL M. HAACK, JR., Technical Note 40, *Alaska Forest Research Center, U. S. Forest Service.*

Lightning-Strike Recorder Rings for Lookout Firefinder Maps

Since 1954 Region 1 has been experimenting with aluminum rings of different sizes placed over the map disks on firefinders. Lightning strikes were recorded on the aluminum with pencil as they occurred. When the temporary record was no longer needed it was easily erased. These experiments have led to a new method which appears to be very satisfactory. All firefinder maps in Region 1 will be mounted as follows:

1. The maps are cut $1\frac{1}{4}$ inches in diameter smaller than the metal required, leaving a $\frac{5}{8}$ -inch margin of bare metal.



2. 3S aluminum sheets .018 grained on one side, are used. Grained aluminum is ideal for pencil marking and the marks are easily removed.
3. The map is bonded to the grained side with dry-mounting tissue. A large electric dry-mounting press is heated to 230 degrees and approximately 10 pounds of pressure per square inch is applied. After 45 seconds the pressure is released and the map is turned 90 degrees. Pressure is again applied for another 45 seconds.
4. The mounted maps are made water repellent by spraying with aircraft industrial lacquer.

On some makes of firefinders (old-style Bosworths) the metal azimuth circle covers the perimeter of the map. If this is the case, allowance must be made by cutting the map smaller before mounting and spraying.—A. R. FINK, Missoula Equipment Development Center, U. S. Forest Service.

HOW EASTERN REGION FIRE TRAINING COMMITTEE FUNCTIONS

A. R. COCHRAN

*Former Fire Chief, Section of Fire Control, Region 7,
U. S. Forest Service*

A public awakening to the strategic place of resources in national existence came out of the world war experience. Old standards of protection were recognized as inadequate. New higher standards were required. Protection agencies faced a changed situation. Disastrous fires over widely separated areas of the country gave a sense of urgency to the situation. Losses formerly tolerated were no longer acceptable. Resource managers needed answers to the problems of resource protection. They needed to be equipped and trained for a job always different, but which now required much more exacting standards.

Training seemed to offer one of the most promising opportunities for strengthening fire control rapidly. This Region sought to meet the urgent training requirements through a task force approach. A Regional Training Committee was activated to analyze training needs, develop a training program, and apply it in the Region. Membership of the five-man committee consisted of three qualified firemen from the forests, the regional fire specialist on fire studies, and the regional fire staff officer.

The first work of the committee consisted of assembling information on fire control subjects as complete and authoritative as possible. The findings of research, the well-established standards and techniques of fire control, and the experience of fire control people were brought together. Fire weather and fire behavior studies furnished an important part of the information assembled.

The committee decided that in preparing a program emphasis should be on principles. The reason for adopting such a guide was to equip the administrative officer with principles and natural laws as the tools required for solving the multiplicity of situations which he will face in resource protection. Fire control subjects treated in this way attained a scientific stature as against a system of dogma, rule of thumb, and special problem solving which at best could be applied rigidly and often crudely, never quite fitting the problem on the ground.

The first step in developing an overall training program was to prepare an outline of subjects important to fire control and related to training needs of the Region. These subjects were apportioned into yearly training programs representing priority of subject matter and limited to what could be covered reasonably in the time available during any one year.

After the subject matter for a year's program was selected, the committee made an exhaustive analysis of each subject and arranged material in logical sequence. They limited subjects to those bearing on principles. This assisted the committee in sorting the pertinent from the nonrelevant. This phase required about one week of committee work for each year's training program.

Each subject was defined, and assigned its proper place in the training outline.

Each major subject is broken down into instructional units which the following illustrates:

What: Define subject.

Why: State the specific function or place of the subject and the reason why it is included.

The subject is broken into teaching units:

<i>Lesson plan No.</i>	<i>Instructional units</i>	<i>Scope of instruction</i>
1	Name of instructional	Define the limits or
2	unit for each lesson	bounds of instruction,
3	plan.	giving specifically
4		the area to be included in each lesson plan.

This process of stating the what and the why of each subject requires clear thinking and is the means of separating principles from nonessentials.

Because this outline information provided insufficient guide for the actual training job, a text was prepared. This gave fluency to the subject matter and provided a flexibility that paid off well for the time and effort required to make the writeup.

Lesson plan development was in accordance with professional standards; used as a reference was "Techniques of Military Instruction," FM 21-6, Department of the Army Field Manual, May 1954. The committee's big responsibility in lesson plan development was to find training techniques that carried an impact for fire control subjects. This is a fertile field for attention. In addition the committee had to adapt training techniques to the resources available on a forest.

Lesson plans, however carefully prepared, should not be released for general use until they have been proved in a training session. The experience of the training committee has been that some very worthwhile and needed adjustments have been made through the regional test training session. The trainees in the regional training session are responsible for forest training in these subjects and are naturally keen and alert. They are quick to detect weaknesses and ready to make changes that show they are needed.

A considerable amount of time must be spent by the fire specialist and regional fire staff man in preliminary work on a training session. This includes time for consultation with fire research people.

The training committee has used 5 to 6 weeks in session to produce a training program for a given year. In addition to the time in consultation, members spend whatever time is required, individually, on the subjects for which they are assigned responsibility for teaching in the regional training session. Because they have individual responsibilities for producing results, each is inclined to take his "homework" very seriously. Although committee members had to devote a significant amount of time, their efforts were justified by the results obtained. Attention to the technical soundness of the training material developed and to training techniques has paid off in effective fire control training.

SLASH DISPOSAL BY BURNING ON THE KLAMATH

LEE MORFORD

Forest Dispatcher, Klamath National Forest

Beginning with the World War II years, the cost of slash disposal increased to such an extent that disposal and hazard reduction became less common on forest lands. Personnel on the national forests of California began searching for a cheaper method to accomplish the desired results from both a fire hazard and silvicultural standpoint. When the logging industry moved into the Douglas-fir area of northwestern California a new fire problem faced the protection agencies. In the Douglas-fir timber a cull volume ranging from 20 to 50 percent of the total volume was left on the ground following logging. This created a very heavy accumulation of both large and small fuels. Fires occurring in these fuels were extremely difficult to control, particularly when fire dangers were above the low range.

Late in 1952 a study was made of the fires occurring in the Douglas-fir type slash areas of northern California. This study indicated that, if protection goals were to be met, some method of slash disposal would have to be instituted in spite of the heavy costs.

The Klamath National Forest took the lead in attempting to devise ways of disposing of the heavy accumulation of fuel so that fires in the slash areas could be controlled. The Happy Camp District was designated as an experimental area. Fred Wilder, who has an excellent knowledge of fire behavior, was assigned to the project. He treated the areas in several different ways and kept cost records on the treatments. It soon became apparent that if slash burning was to be done safely and economically, all district managers would need established guidelines. The costs could be prohibitive if burning was tried when fuels were too wet; burning was unsafe when fuels were too dry.

The problem had been discussed with the California Forest and Range Experiment Station at Berkeley and the fire weather section of the Weather Bureau. It was decided to set up a series of weather observation stations to get a representative measure of weather conditions in the timbered belt. By correlating their observations with the burning being done under the supervision of Fred Wilder, and through trial and error in other slash burning projects, it was possible to establish a set of preliminary guidelines to slash burning for use by all districts on the forest.

During the fall of 1956 the new guidelines were put into full use forest-wide. Weather observations were taken at the Humbug Fireman Station and Scott Bar Mountain, Slater Butte, and Blue Ridge Lookouts. The lookout stations were at the upper edge of

the timbered areas in which the slash was being burned and the Humbug Fireman Station at the lower edge.

These observations were correlated with the burning projects on the Happy Camp District, to serve as a basis for revising and improving the preliminary guidelines, for which burning indexes had been computed from our Fire Danger Rating System. The revised system was used again in 1957 and a record was kept of the intensity with which the slash burned. Using this record and correlating it with the observed weather conditions and the previously established indexes, we again broadened and improved the guidelines.

The procedure under the guidelines is as follows: Observations are taken from selected stations prior to the beginning of the slash burning. Weather forecasts are received twice daily during the month of October and once each day thereafter. From these weather forecasts and from the computed indexes of the day before, the burning index is predicted for the next day. This predicted index is then given to all districts engaged in or planning slash burning.

No burning is done prior to October 1, and then not until at least $\frac{1}{2}$ inch of rain has fallen. The guidelines and the indexes are used to determine where and when the slash can be burned safely and where and when the slash can be burned without too great a cost. In other words, when the burning index is zero, it is a waste of manpower and money to try to burn the lighter fuels. Heavy fuels that have been piled with some type of protection from weather can be burned at any time when there is no danger of spread.

To take advantage of every day of good burning conditions, it is advisable that work crews have a staggered tour of duty. It is also best to have men available to check areas that have been previously burned under favorable conditions whenever the increasing burning indexes indicate that there is danger of spread.

This system does not entirely eliminate all risk in burning slash since weather predictions are not always dependable and very often the weather prediction is not representative of small isolated areas. Either one of two methods is recommended for overcoming these deficiencies. (1) Place a person in charge of the burning operations who has a good understanding of fire behavior and a background of experience in slash burning, or (2) have a portable weather station available at a selected site near the burning project where observations may be taken during selected periods throughout the day. Either of these two methods work satisfactorily and prevent unpredicted severe burning conditions from trapping the burning crews or catching them with fires that they may be unable to contain and that may become costly.

TYPICAL SLASH BURNING GUIDELINES

1. Slash burning will not be permitted until after October 1, and then not until the following conditions are present and requirements met.
2. Trends of the fire danger for Area 8 must be available for at least 5 days prior to burning, except that burning may be started immediately after at least $\frac{1}{2}$ inch of rain has fallen.

3. Slash may be burned in these situations after $\frac{1}{2}$ inch of rain and the Area 8 index trends are as indicated.
- a. In shaded canyon bottom; index below 17.
 - b. North exposure, about 6,000 feet elevation; index below 15.
 - c. North exposure, fir type, 3,500 to 6,000 elevation; index below 12.
 - d. North exposure, pine or mixed conifer type, 3,500 to 5,000 elevation; index below 10.
 - e. Piled slash along lower side of roadbed, or slash piled and lined with firebreaks, fir and Douglas-fir types; index below 10.
 - f. East, south, and west exposures, Douglas-fir slash, 2,500 to 6,000 elevation; index below 10.
 - g. East, south, and west exposures, mixed conifer and pine, below 5,000 feet; index below 7.
 - h. Ridgetops and exposed points, pine and mixed conifer, index 3; Douglas-fir and fir, index 5.

CONCLUSIONS

The hazard reduction done on the Klamath since 1950 has not been fully evaluated. However, in 1955 during one of the most severe fire seasons in the history of the forest, an incendiary fire was started in unburned slash. It spread to an area in which the slash had been burned. This fire was controlled during the first burning period after spreading over approximately 800 acres. The fire overhead stated that only because of the previously burned slash were they able to construct and hold firelines. This fire was one of 28 that started on the forest between September 1 and September 5. Several of these 28 fires were disastrous, and a total of approximately 64,000 acres of timberland were burned over in the first 10 days of September.

The Klamath is crossed by a very large lightning belt and no part of the entire forest is exempt from lightning storms. It is not uncommon for 30 to 70 fires to be started from a single thunderstorm. With the cutover area increasing at the rate of 5,000 to 10,000 acres a year, the risk of lightning fires and the potential disaster resulting from them is continually increasing. This situation alone makes it imperative that adequate hazard reduction be employed. We believe that, by using these guidelines for reduction of hazard, we will be able to meet the objective of both fire protection and silvicultural management of cutover areas.

SLASH DISPOSAL BY DOZER, NORTHERN ROCKY MOUNTAINS¹

In 1952 the U. S. Forest Service started a project that included an analysis of dozer-piling methods for slash disposal in the clear-cut lodgepole pine type, with attention to effects on regeneration. Advantages and limitations of dozer piling were to be determined and a comparison of machine sizes (dozers), production, and cost made. In 1953 the larch-Douglas-fir and ponderosa pine types were included.

During 1954 and 1955, dozer bunching or piling of slash was used on approximately 33 percent of the acreage and 40 percent of the volume prepared for disposal in the Northern Region (Region 1) of the U. S. Forest Service. It is entirely possible that at least 50 percent of the volume will be handled by this means within the near future.

Specific cost data were particularly difficult to obtain because of many variables such as type of blade, volume, slope, ground condition, experience and skill of operators, and contract rate. It was also extremely difficult to measure results of slash disposal proper against incidental stand-improvement and other work. It was not possible to establish the necessary controls for absolute accuracy in cost and production analysis. This report, however, is prepared from such figures as we could get and have analyzed by the most experienced men available. Although it falls far short of the desirable, it should be helpful in planning machine operations.

MACHINE SIZE

In general, men experienced in machine slash disposal favor the larger machines, such as the crawler type D-7 or D-8 (fig. 1). Dozers comparable in size and power to the D-7 or D-8 have been most widely used; however, machines comparable to the D-6 have also been satisfactory from the cost and production standpoint. Many men who formerly considered only the larger machines have been swinging to the D-6 size class because of transportation, availability, and other advantages attributable perhaps to local considerations or conditions.

The production of a D-4 size machine was analyzed for only one job. Results were not considered favorable to general use of the smaller dozers. These small machines have trouble in handling slash where stumps are present in any quantity or where there is extensive windfall. Although the general use of dozers in the D-4 size class is not recommended, they have unexplored possibilities where cut per acre is light and other factors are ideal. On good ground they are highly maneuverable and may have a place when compared to the alternative of hand piling.

Contract dozers in the D-6 class have been available for \$9.75 an hour; dozers in the D-7 class for \$11.75; and dozers in the

¹A somewhat shortened version from *Mechanized Slash Disposal*, compiled by H. K. Harris. U. S. Forest Service Equip. Devlpmt. Rpt. No. 43, 27 pp., illus. 1956.



FIGURE 1.—Slash disposal dozer. Note heavy armor and cab protection.

D-8 class for \$12.50. These rates include operators. They vary somewhat by areas and according to the availability of other work.

RATING AN AREA FOR DOZER WORK

Because cost and results vary according to the difficulty of a slash-disposal job, the relation between obstacles and ease of production are of importance in planning. Therefore, the following factors must be considered:

Slope.—Although dozers can operate on slopes steeper than 35 percent, production falls off so rapidly that costs become prohibitive.

Windfall.—Some areas contain sufficient windfall to definitely hinder the slash-piling effort, particularly if long and large stems are involved.

Snags.—Standing snags represent a considerable hazard to the operation; the number per acre is important in any attempt.

Rock outcrops.—Rock slows down tractor maneuverability and handling of the blade.

Reserve stand.—Reproduction and larger trees that must be saved influence rate of production. This factor is also a consideration in the selection of slash-disposal methods.

Boggy ground.—Soft ground not only limits tractive effort but can tie up a dozer team for long periods. It is often a consideration in selecting the time or season of operation.

Soil characteristics.—Light soil types, such as those common to true white pine types, provide poor traction even under ideal condition.

Slope should probably be the major consideration in rating an area for ease of production with dozers. In one study where slash was bunched on 69.8 acres by a TD-18 dozer equipped with an Isaacson brush blade and operated by a skilled operator, the time required per acre almost doubled when slope increased from 20 to 35 percent.

The following tabulation, based on observation of dozers at work and discussions with field men, can be used to rate an area in respect to the possibilities of dozer slash piling.

Factor:	<u>Ease-of-production classification</u>		
	<i>Easy</i>	<i>Average</i>	<i>Difficult</i>
Slope .....percent.....	Less than 15	15-30	More than 30
Windfalls per acre .....number.....	0	1-10	More than 10
Reserve stand,			
stems per acre .....do.....	Less than 5	5-10	More than 10
Snags ¹ per acre .....do.....	Less than 3	3-10	More than 10
Rock outcrops, area .....percent.....	Less than 3	3-10	More than 10
Boggy ground, area .....do.....	0	1-10	More than 10
Very loose soils,			
reduce slope factor .....do.....	0	5-10	More than 10
Reproduction stocking ² .....do.....	Less than 15	15-50	More than 50

¹General definition given by field men, "Any dead stem left standing, following logging, over 6 inches d.b.h. and 10 feet in height."

²Percent stocking based on 4-milacre units.

PRODUCTION AND COST

An analysis of production showed that dozers in the D-7 or D-8 size class, properly equipped, and operated by experienced men, can be expected to average 2 acres an hour in areas rated "easy"; 1.2 acres per hour in areas rated as "average"; and .67 acres per hour in areas rated as "difficult."

For each thousand board-feet of timber logged, cost of machine piling slash averaged less than a dollar on easy areas, \$1.25 on average areas, and \$2.35 on difficult areas.

The following factors in addition to those determining ease of production also influence cost:

Volume of slash handled.

Acreage or size of operation.

Transportation and nonproductive machines and labor.

Size, condition, and number of machines.

Skill of operators.

Field supervision.

Amount and kind of stand-improvement or other work done in conjunction with slash bunching.

Time and season.

Contract or Government-owned dozers.

The species handled in a dozer operation may also have some influence upon cost. Studies are under way to determine the volume of slash to be expected in various timber types and its relation to sawtimber volume. It is known that the volume of slash per thousand board-feet of timber logged is much greater in young stands than in mature stands. Six trees 12 inches d.b.h. produce approximately the same scale as one tree measuring 24

inches d.b.h., but the large tree produces only about half as much slash as the 6 smaller ones.

In the study reported here, slash accumulations were not measured for volume. However, the extent to which volume of slash influences cost is reflected in the cost of dozer operation, not including overhead, according to the volume of timber logged per acre as follows:

<i>Volume logged per acre (M board-feet)</i>	<i>Cost of dozer piling per acre (dollars)</i>
5	10
10	14
15	19
20	23
25	27
30	31

Note that an increase in volume of timber logged per acre will, in general, result in a reduced cost per thousand board-feet for the dozer operation. The reason for this is obvious. Noneffective dozer operations, such as backing and turning, are reduced as the volume logged per acre, and hence slash, increases.

Small, isolated areas with light volumes of slash may be more economically handled by hand-piling than by dozers, since contract rates or transportation costs for dozers raise cost considerably. On the other hand, relatively small areas with heavy volumes of slash may be more economically handled by dozers. The deciding factor may be site ease-of-production classification ("easy" or possibly "average"), the amount of stand improvement, or possibly benefits from dozer bunching such as scarification and seed distribution.

OPERATIONAL TECHNIQUES

Carefully planned and executed operational techniques may make the difference between an economical operation or one that is costly. For example, in the investigation reported here, time studies were made to establish a "pattern of operation" for dozer piling slash on a clear-cut lodgepole area which included considerable stand-improvement work. The time studies took into account (a) distance of drift slash, (b) effect of standing trees and stumps, (c) blade capacity and allowable loss of slash from blade, (d) pattern of dozer movement, and (e) windrowing of slash vs. bunching or piling.

As a result of the time studies, production for the particular situation considered was increased from approximately 1 acre per machine-hour to 2.25 acres. This was accomplished by—

Increasing distance of each swipe to approximately 2 chains
Although some sloughing was experienced, it consisted principally of slick stubs and poles with only a few branches which are not a serious fire hazard when left on an area.

Reducing the noneffective time spent in maneuvering the tractor by backing through finished area and crowding new slash when moving forward.

Windrowing slash instead of piling. In this instance, the windrows required less nonproductive maneuvering of the tractor.

The pattern of operation may require considerable variation to fit conditions. The training of operators, particularly with respect to pattern of operation and degree of cleanup required, is essential to the success of every job. The following matters should also be considered by supervisors in planning slash disposal:

1. Avoid machine piling in areas too steep for economical operation. Weigh production against operating time as a check.

2. On some sites, machines are not practical because of the volume and spacing of reproduction or seed trees that must be left. The big machines, with wide blades, cannot operate without pushing many trees down and damaging considerable reproduction.

3. On sites where soils are easily eroded and steep slopes predominate, dozer operations may not be desirable. Use of dozers may contribute to the erosion problems created by the logging operation.

4. The amount and kind of stand-improvement work should be considered. Dozers can push over residual trees in many stands better, faster, and cheaper than hand labor can. When both stand improvement and slash disposal are done concurrently, the overall job is simplified.

5. Select the proper season for dozer operations. Some areas do not dry out until late summer and much trouble will be experienced if machine piling is started too early. Dozers cannot operate successfully on steep ground (20 to 35 percent) when it is frozen. Sometimes the difference between morning and afternoon frost conditions, particularly on north-facing slopes, is a factor.

6. Slash is more easily handled if it has had a month of drying weather. Where maximum seed distribution is desired, the cones from dried slash are easily shaken from the branches and scattered throughout the operating area. In some timber types, however, excessive scatter of cones and seed from dry slash may result in undesirable, overdense stands; it may be advantageous to bunch such slash as soon after cutting as possible.

7. Select the proper size dozers. In lodgepole clear cuttings for example, the stumps are too numerous to avoid and must often be pushed out by the blade for maximum production. Small dozers have not proved practical.

8. Whether contract or Government-owned dozers are used, give particular attention to service and repair. Fuel barrels are a poor substitute for a tank wagon because of lost handling and fueling time. If barrels are used, they must be kept clean and free of rust and scale. A 15-gallon drum should be available for oil changes. Each dozer should carry an extra hoist cable, and other cable should be kept on hand. There should be extra grouse plates (with bolts) for tracks. A supply of extra filters for oil changes should be available.

9. All dozers must be equipped with substantial cabs. All men must wear hard hats. Ground workers should be kept at least 200 feet from dozers at work. Special and detailed safety plans, instruction, and inspection are necessary.

10. Use dozers in pairs if the job is large enough. This will reduce lost time on soft ground or when the dozer gets "high-centered."

11. In heavy windfall or snag areas, use a helper with a power chain saw, especially with machines of the D-4 or D-6 size class.

12. It is important that the cleanup around the perimeter of each unit be better than average. This will provide a safety factor if burning operations are conducted during windy or dry weather, a condition that often occurs during the early fall. The pattern of cleanup may often be arranged to provide additional safety by means of separator strips, where the slash piling is given special attention.

13. Keep a qualified foreman on the job. It should be his responsibility to—

a. Do the current planning on an operation; i.e., where to use dozers or hand piling on an area; where slash should be left to prevent erosion; and other necessary details. Conduct time studies, as necessary, in order to reduce noneffective maneuvering of machines to a minimum in establishing a pattern of operation.

b. Direct operations when windrowing, piling, scarification, and stand-improvement work are done concurrently.

c. Keep dozers spaced for safety of operation but close enough that they can assist each other when necessary. Check work of operators frequently to prevent unnecessary "polish" as well as inadequate cleanup.

d. Avoid working dozers in smoke and under conditions of reduced visibility when burning is done in connection with piling.

e. Check operators on proper maintenance of Government-owned equipment. (Operators should follow manuals carefully regarding service periods; brush blades are heavier than regular blades and front idlers require extra attention. Fuel tanks should be filled each night to avoid condensation, and the last hour of a shift should be used to grease, fuel, and tighten bolts.)

f. Keep a daily record of running hours for each dozer. Settle with dozer operators (contract equipment) on actual running time each day. Prepare accurate progress maps and cost data necessary to report and analyze accomplishments.

EFFECTS OF BUNCHING ON REGENERATION

Prompt restocking to the right density and with the most desirable species is at least as important a management objective as harvesting the timber stand. The problems of regeneration differ with areas, timber types, and methods of logging and slash disposal. In discussing the effects of dozer bunching on regeneration, it must be recognized that the acceptance of a single method of slash disposal is not recommended. Each

slash-disposal method possesses certain advantages and disadvantages that must be weighed carefully before selecting one to apply to a given stand or condition.

Lodgepole pine type.—Clear cutting in blocks of various sizes, depending upon conditions of topography, wind, and other factors, is the common practice in pulpwood cuttings in the lodgepole pine type of Montana. After pulpwood clear cuttings, only small or occasionally large defective trees remain. Therefore, trees that occupied the area before cutting and the trees in the surrounding uncut timber furnish the principle source of seed. Seed dispersed from surrounding timber is chiefly limited to the margins of the cutting area, and the small amount of seed dispersed beyond 3 chains is inadequate and undependable for reproducing a stand. Therefore, seed dispersed before cutting and seed on cones attached to slash and in individual cones scattered over the ground undoubtedly accounts for most of the supply for regeneration.

Since some slash disposal is usually necessary to reduce the danger of fires in logging debris, an understanding of the effects of disposal on natural regeneration is important for planning successful renewal. Most publications concerning lodgepole pine regeneration place considerable emphasis on slash-disposal methods; however, they differ widely in conclusions and recommendations.

The White Sulphur Springs area, where most of the information for this discussion was collected, contains pure, even-aged, overmature stands growing at elevations of 6,500 to 7,500 feet. Soils are generally clay and silt-clay loam composition. The results reported here should be applicable to similar stands in Montana and elsewhere.

Preliminary observations of broadcast-burned and unburned clear cuttings indicated that effects of slash disposal were closely associated with the available seed supply. Sparse reproduction was found on burned seedbeds created either by broadcast burning or burning of piled slash. Abundant reproduction was found on unburned seedbeds. Much of the seed and cones were destroyed by the fire which accounted for this difference. If the fire from broadcast burning covers the major part of an area, average reproduction will be exceedingly low.

The amount of regeneration observed in a stand of lodgepole pine, according to seedbed, is given in the tabulation that follows.

	Seedling distribution, stocked micacre quadrants			Density of trees per acre,
	1950 (percent)	1951 (percent)	1954 (percent)	1954 (number)
Seedbed:				
Burned, piled slash	15	15	28	860
Burned, windrows	24	18	28	720
Slash, windrows and concentrations	38	28	45	1,880
Forest floor	78	74	80	7,010
Skidroad	95	88	96	10,380
Scarified	83	81	88	10,730
Slash, lopped and scattered	83	76	82	9,910

Since the regeneration on undisturbed forest floor exceeds the present concept of optimum stocking and number of seedlings per acre, scarification or scattering of seed as a result of dozer piling cannot be considered an advantage (fig. 2). If fire-hazard reduction were not required, the best treatment would be to leave the slash in place. Future stocking in the stand will presumably level off or increase very slowly. Viable seed has been found in cones attached to 6-year-old slash.



FIGURE 2.—Lodgepole reproduction in scarified ground 5 years after slash was piled.

Dozer piling in the lodgepole type is advantageous in that it permits controlled burning of slash, thus limiting the total burned area; it also permits the economical destruction of defective and diseased trees (fig. 3).

Research was begun in 1955 to determine the value of dozer bunching as a control of regeneration in areas where distribution and supply of seed are overabundant. It may be possible to bunch cone-bearing slash before it dries and the seed is easily shed. This would not only reduce the seed in scarified areas between



FIGURE 3.—*Top*, Machine-piled slash in lodgepole clear-cutting area. *Bottom*, Slash disposal and stand-improvement work combined on clear-cut lodgepole pulpwood sale.

windrows or piles, but more cones would be consumed by the burning operation. First results of the study have produced some leads as to when the slash might have to be removed in order for the control to be effective.

Also important to the slash problem, but not necessarily directly related to machine slash disposal, are observations regarding the fire hazard of undisposed slash in the lodgepole type. In areas where no slash-disposal treatment was undertaken, and in areas where lopping and scattering was done (fig. 4), the fire hazard remained at a level higher than was acceptable to fire control men 4 years after needle fall. Needle fall, which took place within two growing seasons after logging and one growing season after disposal, was assessed as having dropped the rate of spread one class.²

Larch-Douglas-fir type.—Dozer piling is generally regarded as conducive to good regeneration in the larch-Douglas-fir type in Montana. In the average logged-over larch-fir stand, only 10 to 20 percent of the area is disturbed sufficiently by logging to provide favorable seedbed conditions. Dozer bunching provides additional favorable seedbed where slopes are not too steep and dozers can be economically used.

One study of cutting practices in Montana larch-fir type revealed that stocking was generally adequate in the three cutting methods used where the slash was piled by bulldozer and brush blade and/or burned. The results are shown in the following tabulation:

<i>Cutting method and slash-disposal treatment</i>	<i>First-year seedlings per acre</i>	
	<i>Western larch (number)</i>	<i>Other species (number)</i>
Seed tree:		
Hand pile and burn	259	247
Dozer pile and burn	4,598	2,725
Spot burn	1,799	464
Shelterwood (economic selection):		
Hand pile and burn	545	545
Dozer pile and burn	5,692	331
Spot burn	6,228	703
Shelterwood (vigor selection):		
Hand pile and burn	1,144	1,468
Dozer pile and burn	9,509	2,204
Spot burn	10,592	1,941

As a result of slash-disposal treatment, favorable seedbed area ranged from 35 to as much as 80 percent. The hand-pile and burn treatment, for the three methods of cutting, resulted in the lowest stocking because of the lack of favorable seedbed.

In some areas the use of bulldozers on slopes of 30 to 35 percent, and even on gentler slopes in some soils, may induce soil erosion and hasten runoff to an undesirable extent. Because of the importance of soil scarification and removal of intermediate and low vegetation, this aspect of the problem needs more study.

Prescribed burning is the only known method for preparing seedbeds on slopes greater than 35 percent. It is risky and difficult. All indications point, however, to the superiority of mineral soil as produced by scarification and burned forest floor for germination and establishment of larch reproduction.

²Fuel classification currently in use in Region 1 divides fuels into 5 rate-of-spread classes known as low, medium, high, extreme, and flash.



FIGURE 4.—Lodgepole clear-cut area 5 years after slash was lopped and scattered.

Ponderosa pine type.—Studies show that mineral soil will produce approximately eight times as many seedlings per acre as natural duff under similar conditions. A mineral-soil seedbed can be obtained either through burning or scarification. Where rodents are a problem, the scarification produced by logging and supplemental machine slash piling, and the exposed soil resulting from burning, may make the difference between satisfactory and unsatisfactory restocking. In one instance, rodents destroyed 92 percent of the seed.

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INFORMATION FOR CONTRIBUTORS

It is requested that all contributions be submitted in duplicate, typed double space, and with no paragraphs breaking over to the next page.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and unit.

Any introductory or explanatory information should not be included in the body of the article, but should be stated in the letter of transmittal.

Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints are acceptable. Legends for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the legend being separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the type page proportions in mind, and lettered so as to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands. *Paper clips should never be used.*

When Forest Service photographs are submitted, the negative number should be indicated with the legend to aid in later identification of the illustrations. When pictures do not carry Forest Service numbers, the source of the picture should be given, so that the negative may be located if it is desired.

India ink line drawings will reproduce properly, but no prints (black-line prints or blueprints) will give clear reproductions. Please therefore submit well-drawn tracings instead of prints.



**Smokey's
Commandments**

**BREAK MATCHES
CRUSH SMOKES
BE SURE ALL
FIRES ARE OUT!**

**Remember-
Only you can**

PREVENT FOREST FIRES!

766FI

FIRE CONTROL NOTES

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A PERIODICAL DEVOTED
TO THE TECHNIQUE OF
FOREST FIRE CONTROL

FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.

FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the
TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

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Forest Service, Washington, D. C.

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RADIO PROCEDURE—YOUR KEY TO EFFECTIVE OPERATIONS

JOHN H. ATKINSON
*Assistant Communications Director,
County of Santa Clara, California*

The use of radio as a major weapon in fire control activities as well as in general forestry operations has progressed at such a phenomenal pace since the end of World War II that many users have lost sight of proper operating procedure. Radio equipment is now installed in vehicles operated by State foresters, and in dozers, helicopters, and other Service equipment. The ability to utilize the full potential of these adequately equipped radio systems is fully dependent upon proper procedures and practices. Your system is only as good as your worst operator.

Good operating procedure must start at the top administrative level and carry down through the lowest unit by training and example. A standard operating procedure manual describing the radio system in nontechnical terms is the first criteria for successful operation.

The manual should contain the complete procedure as applied to field forces, including many examples of typical transmissions so that even the most unfamiliar crewman can substitute his own case for the example and find a usable message.

Each employee who will operate the radio must be issued a procedure manual. Each station, whether radio equipped or not, should have sufficient manuals assigned to it so that all employees can have an intimate knowledge of proper operating procedures. Prime examples must be set by the dispatcher, rangers, and other supervisory employees. A supervisor who uses sloppy procedure cannot expect anything better from his employees. The ranger, his assistant, or the dispatcher should spend as much time as possible instructing new personnel in proper radio usage before they are permitted to operate. Only in this way can reasonable success be expected. In large forestry agencies, administrative communications personnel should be employed to help in these matters and to provide nontechnical communications assistance to Fire Control and other policy divisions.

STATION IDENTIFICATION

Each base station is assigned a Federal radio call sign, generally 3 letters and 3 numbers. This call sign is the legal identification of the station. In a large system, the number of call-sign combinations is excessive, and the radio channel is a mass of confusing letters and numbers. Obviously this makes it difficult, if not impossible, to remember the call sign of every station. Under such circumstances, geographical call signs are preferred. These are assigned by the system administrator and generally are the name of the ranger station, lookout, or activity where the radio is located.

The geographical call sign is used in all communications between stations and between stations and their respective mobiles. If the Miami Ranger Station calls the Bass Lake Guard Station, the transmission would be as follows: "Bass Lake—Miami." You will note that the name of the called station is transmitted first, followed by the name of the station doing the calling. If the order is reversed, *all* base stations must listen when they hear "Miami" in order to determine whether the call is for them. By using proper procedure, the called station is alerted in time to hear the identification of the station making the call.

The assigned legal call sign must be given at the end of each transmission or series of transmissions. This means the full call, including both letters and numbers, because the use of only the numbers is a violation of the Federal regulations for station identification.

Stations used as temporary base stations are in many cases licensed to only a single call sign, such as KMB453. The licensee then must add a unit identification to the call, such as "Unit 1, KMB453; Unit 2, KMB453." The use of the geographical call sign would still apply to these units, however; in signing off at the completion of the transmission they would identify as "Unit 1, KMB453."

MOBILE IDENTIFICATION

Most mobile units and handie-talkies are identified by unit number and there are few problems. Several methods are used in establishing uniform mobile identification. For example, California employs a four-number identification for all units. The State is divided into six districts for administrative purposes. The 1st digit of the 4-number assignment identifies the district; the 2nd, the ranger unit; the 3rd and 4th, the unit or vehicle number. For example 5424 would be vehicle 24, in ranger unit 4, district 5. Such a mobile identification system eliminates confusion and readily identifies all units.

As in other transmissions, the mobile identification is used first when being called by a base station—"5424—Miami." The mobile need only state his number to signify that he is receiving the call. Other phrases such as "5425 bye," and "5424 go ahead," are not necessary. Because of the increased use of radio-equipped aircraft, the mobile identification number, or a part of it, should be painted on the roof of each vehicle to facilitate air-to-ground identification and communication.

GENERAL PROCEDURE

The strictest procedure possible without loss of efficiency is to be desired. All personnel should be cautioned to keep all messages brief and to the point. One fault common to many operators is their inability to know when they start to repeat themselves. Give the message in brief detail; if more information is required, the other station will ask for it. It should not be necessary to ask initial attack units for an appraisal prior to their arrival at a fire. Good forestry procedure requires that the first

unit issue a size-up on arrival. Likewise, lookout reports should be precise and in a predetermined manner. How many times have you heard a lookout give a very detailed report and then have the dispatcher ask "What's it look like?"

All personnel should be impressed with the need for monitoring the radio channel prior to transmitting. Nonmonitoring causes interference and unnecessary repeats. Particular attention should be given to this by lookouts and aircraft. From high elevations, signals travel many miles and cause considerable out-of-area interference.

One other common fault that increases radio traffic usually occurs at the dispatcher level. General-information broadcasts are transmitted to several stations and/or mobiles by the dispatcher. He signs off with "All units acknowledge" or similar phraseology. The acknowledging units then do as requested, and usually at the same time. This results in a jumble of acknowledgments and many repeats become necessary. It is desirable that the dispatcher at the completion of his broadcast state each station's name or mobile number in order and obtain an acknowledgment before going on to the next one. This is a little more work, but the results are positive because in the long run traffic is reduced.

CODES

A standard radio code that uses numbers to replace standard phrases should be adopted for use by all personnel in a system, because it materially reduces radio traffic. Such a code is given at the end of this article.

LOGGING TRANSMISSIONS

The method of logging a dispatcher's messages varies between agencies, but generally it is done word-for-word in a page-type radio log. In the initial stages of a going fire, the assistance of a second person is usually needed to keep the log up to date. Units going in and out of service are lost in the log pages, and continual rechecking is necessary to find them. Actually, the Federal Communications Commission's Rules and Regulations under which non-Federal agencies operate require logging only the name of the operator of each base radio station (ranger, lookouts, guard stations, etc.) and his period of duty. Systems administrators should review their procedures to determine whether unnecessary log work is being done. Approximately 90 percent of all administrative broadcasts could probably be eliminated from the logs.

One method of keeping track of units is to use a series of pegs upon which are hung 1½- by 3½-inch white tags with the status of each unit written on them. As a unit reports a change in status, its tag is changed. Thus, the status of each unit is readily available at all times.

Another method of keeping track of units is for the dispatcher to keep a fire-alarm log for each fire. It has a place for first report and the time. Each station is listed in order, and a space is available to record the time each station was dispatched. Also a series of columns is available to show the following: 1, Unit

number; 2, time in service; 3, time canceled and returned to station; 4, time of arrival at fire; 5, time assignment completed and in service to station; 6, time of arrival at station. There is a space for "Control-time" and who reported it. This preprinted form keeps a complete record before the dispatcher of units assigned to a fire as well as their progress in reaching the fire, and it becomes a handy aid in completing the formal fire report.

The amount of radio traffic possible on any radio frequency is directly dependent upon the way the system is operated. One of the most valuable natural resources in fire control today is the radio spectrum. Once radio frequencies become saturated, they cannot be replaced. Only by use of effective operating procedure can we conserve this vital natural resource.

RADIO CODE USED BY STATE AND COUNTY AGENCIES IN CALIFORNIA

All calls not accompanied with the statement code two, three, are routine calls and should be considered code one.

CODE ONE—At your convenience.

CODE TWO—Proceed immediately without siren or red light.

CODE THREE—Proceed immediately with siren and red light.

CODE FIVE—Additional assistance may be needed.

10-1	Receiving poorly	10-48	I'm now ready to take information
10-2	Receiving well	10-49	Proceed to.....
10-3	Stop transmitting	10-55	Confine message to official business
10-4	OK or acknowledgment	10-69	Have you dispatched.....?
10-5	Relay	10-86	Traffic check
10-7	Out of service	10-87	You are to meet.....
10-8	In service	10-89	Need radio serviceman at.....
10-9	Repeat	10-97	Arrived at scene
10-10	Out of service at home—subject to call	10-98	Finished with last assignment
10-11	Transmitting too rapidly/over-modulating	10-99	Unable to copy, change location
10-13	Weather	903	Airplane crash
10-19	Return to your station or returning	904B	Brush fire
10-20	What is your location?	904F	Forest fire
10-21	Call the dispatcher by phone	904G	Grass fire
10-21a	Advise my home I will return at.....	904I	Illegal or incendiary fire
10-21b	Call your home	904P	Plane fire
10-22	Disregard last message	904S	Structural fire
10-23	Stand by	904V	Vehicle fire
10-25	Do you have contact with.....	909	Traffic conditions need CHP
10-36	Correct time	910	Can handle
10-37	Who is the operator?	950	Burning permit fire
10-39	Can.....(Name).....come to the radio?	951	Need C.D.F. investigator
10-40	Is.....(Name).....available for phone call?	952	Report on conditions
10-45	Use code	953	Check smoke
		954	Off the air at scene of fire
		955	Fire under control
		956	You are mechanic

A TRAINING COURSE IN AERIAL SCOUTING

RALPH C. WINKWORTH

*Regional Forester, Division of Forestry
N. C. Department of Conservation and Development*

The North Carolina Division of Forestry has been using both contract and State-owned aircraft for scouting large fires for several years. Most extensive use of this service is in large, inaccessible areas of the Coastal Plain section of the State where aerial scouting has become routine in the suppression of the swamp fires.

Before the State purchased aircraft, the contract system was used exclusively for several aircraft at scattered points to insure coverage. It was found that the success of these scouting flights depended entirely upon the ability of the man in the plane to analyze the problem of the fire boss and to provide him with information that was both accurate and relevant to his suppression problem. It was also discovered that neither an experienced pilot nor an experienced fire control man made a good aerial scouting observer until experience was gained in this particular type of work. Consequently, the time required to get one of the few qualified observers to the plane often offset the value of the flight.

The most practical solution seemed to be to train selected forest rangers throughout the area in the technique of aerial scouting. Beginning in 1951, this training was conducted during the annual ranger training schools for eastern districts. Twelve hours of instruction were devoted to the course, and the course was repeated 3 times during the 2 schools to insure small classes and individual instruction. Several men were able to take the course each year. After acquisition of State planes and employment of regular pilots, this training was on an on-the-job basis, but the same subject-matter structure was retained.

Since all the students were experienced fire bosses, emphasis was placed on the type of information that could be obtained from the air and how it could be transmitted to the ground. This was accomplished through intensive instruction and practice in aerial mapping and radio and message-drop communication.

The course followed this pattern. The estimation of distance and direction in locating a fire and of size in plotting it were approached through navigational methods, and the aircraft compass was used to obtain bearings. After preliminary lecturing, all of the navigation techniques were covered in hypothetical problems worked out individually by the students with assistance from the instructor. This was followed by an orientation flight in a four-place aircraft with the instructor present. On this flight the students located ground points on their maps by plotting bearings from known landmarks and by computing distances by time and speed. The purpose of the flight was to introduce the students to flying.

A second flight was made over a distinct old burn with only the student and the pilot in a conventional two-place scouting aircraft. This flight allowed the student nearly an hour over the burn. He mapped the fireline, sketched in the breaks, determined the cover types, answered questions about the nature of the fire, and dropped messages to a party on the ground. Radio contact was maintained throughout this flight, and the pilot acted strictly on the instructions of the student.

This flight was followed up by a trip to the burn on the ground where the student could compare his impressions from the air with the actual terrain.

The final step was either a third flight or a series of colored slides showing the burn at several angles and from different altitudes. Aerial photos and a type map of the area were also provided after the students had completed their mapping flights.

By using the four-place plane for the first flight, carrying two trainees and the instructor, the cost of instruction per student was kept very low. Most of the men who received the instruction have scouted several fires from the air since receiving this training. They have gained confidence in their ability and are using aerial scouting to a much greater advantage. A short course of this type cannot be expected to fully qualify aerial observers, but the men who have received this training gain proficiency much faster in subsequent actual experience than they would otherwise.



Red, White, or Blue—Wear an extra Shirt on the Fireline

A fire fighters efficiency is often greatly reduced by heat when he makes a direct attack on a fire edge. Tests at Pilgrim Creek on the Shasta-Trinity National Forest, reported by E. L. Alpens, C. P. Butler, and others in Research & Development Technical Report USNRDL-TR-84, NM 006-015.2 in 1955, have shown just how much heat is given off in some common fire situations and also have suggested how to minimize its effects.

The heat received 6 feet away from a wood crib fire was 100 times that received from the sun on a summer afternoon. Less than 1 percent of this is visible since nearly all of a fire's heat energy is in the infrared region of the spectrum. From these facts we can draw two conclusions about proper clothing.

First, the color of a fire fighter's clothing is unimportant in absorbing the heat from a fire because all cloth is "black" to infrared radiation. Also, we know that two layers of cloth are four times as effective as a single layer in reducing the heat penetrating to the skin. Conventional summer underwear fails to give maximum protection because it does not cover the arms and legs. Therefore, a lightweight jacket or extra shirt will reduce the discomfort of close-quarters fire fighting.—ARTHUR R. PIRSKO, *Forester, California Forest and Range Experiment Station*, maintained at Berkeley, Calif., by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of California.

A FOUR-PURPOSE ENCLOSURE CARD FOR TRAINING FILMS

ALVA G. NEUNS

California Forest and Range Experiment Station¹

Motion pictures are excellent visual aids to training when they are used correctly. Using them correctly means that as a part of a training session they must supplement other methods of instruction in a way that increases the speed and effectiveness of learning. We have found that an attractive descriptive folder helps meet this objective.

To make the most of films, a forest officer needs the answers to many questions. Is there a motion picture available on his specific subject? Exactly what part of the training material does it cover? How? Is it an orientation or a skill-training film? What points does it emphasize?

If he happens to be where films are readily available, he can find these things out by the long, slow process of projecting them one at a time. The man at an isolated headquarters is slowed down even more as he waits for review copies to arrive. Descriptive literature can save time for both men, but it needs to be more specific than most catalog listings are about the subject and the training job. When film literature is consistent in form, brief and to the point, and available for all training films, the training leader can use it four ways:

1. To include inside the film can with each copy of the movie. For this purpose it must fit the film can without bulky folds so that it can easily be removed and replaced. The name of the motion picture, its purpose, who it is for, running instructions, and points of emphasis should be identifiable at a glance.

2. To mail out to district personnel concerned with training as an advance notice so that they can consider the movie for use before ordering it. For this purpose, the folder should provide whoever is doing the mailing with the "meat" of the movie. Then he can amplify the material in his letter of transmittal and suggest adaptations for particular training problems.

3. To keep in a file case at district headquarters or training-aids library with similar cards on other training movies and visual aids for handy review when preseason plans are being drawn up. Consistency is most important if the cards are to be usable for this purpose. The cards for each movie should be identical in size and similar in appearance. For easier reference, they can be printed in different colors to denote various subject-matter training series; for example, red and blue for all those used in teaching the use of water on forest fires.

4. To provide a brief guide on how to use a motion picture as a training aid.

¹Maintained by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of California, at Berkeley, Calif.



FIGURE 1.—Printed on standard 8- by 5-inch size stock, the four-purpose enclosure card folds to fit a 400-foot film can.

Two enclosure cards that fit these specifications have been released. Both cards were reproduced on 2 sides of readily available 8- by 5-inch white cardstock. The cards were scored and folded to form a 5-inch square that exactly fits a 400-foot reel film can (fig. 1, A). The folded 3-inch end appears on the left of the card and lists the picture name, what it is about, who it is for, running time, and who produced it. On the right, indicated by small arrows, are the key points emphasized in the film. When the card is opened the key points remain on the right for immediate check reference (fig. 1, C). The ways the movie can be used—plus hints to the instructor—now appear on the left, but are still related to the key points on the right. The back of the folded card contains the material on using a motion picture as a training aid (fig. 1, B).

One of the cards was prepared before making the movie, "Training in the Use of Water on Forest Fires." This card served as a statement of purpose, a base for the shooting script, and a guide to actual filming.

"Capsule" cards like these help state the problem behind every training movie, how it was solved, why, and what the solution can mean to the practical work force. They can clarify the purpose of the movie in advance and serve as a permanent aid to its use.



Turning Pump Motors Over During Storage

Motors of pumps packed in shipping boxes for field use must be turned over every 6 weeks so that the pistons and crankshaft will be in a new position. This helps to retard scarring and etching. Much time will be saved if a 2-inch hole is cut in the box directly in line with the flywheel nut. A socket wrench that fits the nut can then be used to turn the motor. If the motor has a rewind starter, a $\frac{3}{8}$ - or $\frac{1}{2}$ -inch hole can be drilled opposite the rewind handle and the end of a $\frac{1}{4}$ -inch sash cord tied to it; other end of cord is run through hole in box to the outside and a knot tied in it so that it will not slip back in. We have 54 pumps at the warehouse that can now be turned over in 30 minutes. When it was necessary to unpack them, turn them over, and repack them, an average of 30 minutes per pump was required, or 27 hours of labor. Time saved by method that permits leaving pumps in boxes, 26 $\frac{1}{2}$ hours.—ROY O. WALKER, Warehouse Supervisor, Region 6, U. S. Forest Service.

A CAMPAIGN AGAINST HUNTER FIRES

RALPH C. WINKWORTH

*Regional Forester, Division of Forestry,
N. C. Department of Conservation and Development*

Hyde County, in coastal North Carolina, is characterized by vast unbroken swamp and dismal areas of peat soil and flash-fuel types. Ground fires are common during dry summer and fall seasons. Suppression of these ground fires often extends over periods of a month or more until rainfall is sufficient to raise the water table to the burning peat. The State fire control organization in this county is extended to the limit to suppress one of these project fires, and two or more ground burning fires at one time present an impossible situation.

Such a situation was encountered during the opening days of the deer hunting season almost every fall up through 1948. On opening day in 1948, 2 hunter fires started almost simultaneously, and the resulting loss was a total ground burn of more than 20 thousand acres for the summer and fall season.

The prevention problem was unique. Total occurrence in an average year was only ten to fifteen fires representing several causes. Yet the occurrence of two or three hunter fires during late October meant the tremendous loss in acreage. It was decided that the prevention of just one or two fires at the right time would justify a concentrated prevention effort.

Hyde County is sparsely populated and heavily hunted. A large number of the male population are licensed guides, and the county literally lives on the hunting business. By noon on opening day of the 1949 hunting season every hunter and every local resident interested in hunting had been contacted personally with a fire prevention message.

The campaign was centered around a handbill that carried a message of welcome and warning from the local people over the signature of the County forest ranger. The damage from the 1948 hunter fires was cited with an earnest plea for cooperation. In addition to the usual rules of safety, directions were given concerning what to do in the event that a fire was discovered. The law-enforcement angle was introduced indirectly by mentioning the fact that a ranger in a radio-equipped truck was "in your vicinity now" and that his assistance would be prompt upon receipt of a call to designated phone numbers. To strengthen this point, two or three outside rangers assisted in patrolling the county, and both trucks and drivers were changed daily.

Under direction of Hyde County Forest Ranger A. G. Berry, the county was divided into routes and covered systematically beginning one day prior to the season's opening. District Office men were provided with local wardens familiar with the area. Every hunter encountered was contacted, and copies of the handbills were left at every place where hunters might be expected to

visit. All the local guides were requested to distribute bills and to talk to their hunters. Storekeepers cooperated by issuing a handbill to each hunter customer.

On the morning of opening day, the campaign was stepped up by the use of an airplane to drop handbills, wrapped with copies of the forest fire laws, to hunting parties in the woods. Bills were placed under the windshield of every parked car in the wooded area and a patrol greeted each party as the hunters left the woods. This activity was continued in a diminishing degree until the hunting pressure dropped to normal. Radio and press cooperated throughout the campaign.

In 1950, the campaign was repeated with one notable exception. The handbill was revised to center the theme on a message of appreciation from the local people to the hunters for their care and thoughtfulness in preventing fires during the previous year. Similar programs have been carried out with less vigor but with complete coverage in each subsequent year.

It may be stated safely that this campaign has been successful. Several fall seasons since the beginning of the program have been extremely dry, and only one hunter fire has been recorded in Hyde County since 1948, later evidence indicated that there was a strong possibility that this was actually a grudge fire involving local landowners.

It is recognized that this program must be continued indefinitely to assure continued success. Undoubtedly its success to date has been due to the fact that a specific prevention problem in a localized area has been given a vigorous local treatment.



The Ozark Swatmaster—A Swatting Tool For Grass Fires

Control of fast-moving grass fires has always been a problem in inaccessible areas. Limited field tests indicate that the Ozark Swatmaster will be an effective aid in controlling such fires in fields and open glades. Treating the water with a wetting agent may result in more efficient use of manpower and water.

The swatmaster is an adaptation of previous swatter principles, with innovations. Water in the back-pack can is used sparingly to keep the swatter wet. The water flows through a $\frac{1}{2}$ -inch conduit, 5 feet long, which forms the handle of the swatter. The water is channeled by a 4-way pipe T into three $\frac{1}{4}$ -inch feed pipes 4 inches long. Each of the 3 feed pipes has two $\frac{1}{8}$ -inch drilled holes to facilitate flow and distribution of water. The amount of water input to the swatter is controlled by a garden valve set 1 foot from the end of the handle. Flow can be regulated to keep the swatter wet, yet not waste water.

The 16- by 21-inch swatter was made from a piece of salvage, heavy canvas. The canvas was doubled and the edges sewed; a zipper at the top on each side of the handle keeps water escape due to back pressure at a minimum. The three feeder pipes fit into water flues sewed in the swatter. Inside seams allow water to flow into the "water pockets"; they also keep the swatter flat.—JOHN L. KERNIK, *Assistant District Ranger, Missouri National Forest.*

A FIBERGLASS CUPOLA FOR LOOKOUT TOWERS

Alberta Department of Lands and Forests

Until 1953, cupolas used on steel lookout towers of the Alberta Forest Service were made of wood. That year an effort was begun to find a material that would eliminate some of the following undesirable features of the wood cupola: (1) expected lasting time of the cupola is poor as compared with that of the steel tower; (2) erection problems; i. e., too much is left to discretion of the builder, and ratio of weight and bulk to strength is too great; (3) glass width too narrow as compared with corner posts; (4) weatherproof qualities, fair to poor; (5) windows difficult to open in wet weather—loose in dry weather.

During the summer of 1953, all-metal cupolas were designed and manufactured, but they proved unsatisfactory for several reasons. Their construction was far too expensive, and complicated assembly problems arose. Damage to panels and window-frame assemblies occurred in transportation. Repair, such as welding and riveting, was not practical at the tower site.

The next material considered was fiberglass. The Edmonton Transit System had used it as replacement body panels on their buses with considerable success. A rough design for a fiberglass cupola was drawn up and submitted to them for an opinion of its feasibility. The proposal was enthusiastically received, and arrangements were made with E. T. S. for a test on one panel. The first mold was made of plywood, and a rough panel or section of fiberglass was cast. The result proved that further work was warranted. A steel mold, which provided its own complications, was then manufactured.

In July of 1955 a prototype cupola (fig. 1), was completed and declared a success. The total weight of the cupola is approximately 750 pounds, which is roughly two-thirds that of the wooden ones, and the cost is not expected to exceed \$750 per unit. (Cost of wood cupola, \$400.) Due to the nature of plexiglass, the cupola is expected to last as long as the steel tower on which it is erected. Repairs of all kinds can be made at the site without special tools, and maintenance costs have been reduced to a minimum.

The total panoramic view from the cupola has been increased approximately 33 percent, the narrow corner posts facilitating easier use of the fire-finding equipment. Because the wall structure is less bulky, interior space is approximately 20 percent greater than formerly. A double diamond glass with steel frames is used in the windows, and the window slides or frames are made of fiberglass, which eliminates former window troubles. The floor is made of double sheets of $\frac{3}{4}$ -inch plywood nailed on 6-inch centers, thus eliminating floor sills and cupola understructure. The angle beams, which are a part of the tower, provide



FIGURE 1.—The prototype cupola. Each prefabricated flanged panel comprises a wall and roof section as one segment. The panels are formed from fiberglass and polyester resin in a hinged mold that has a steel insert for the window opening.

sufficient support for the $1\frac{1}{2}$ -inches of plywood floor. This floor system eliminates many assembly problems, and 2 men can easily assemble the weathertight cupola in 2 days.

Details of construction and design of the cupola can be obtained on request from the Department of Lands and Forests, Edmonton, Alberta, Canada.

WAR SURPLUS CRASH TRUCK CONVERTED TO FOREST FIRE USE

DON M. POST

School of Forestry, University of Florida, Gainesville, Florida

The University of Florida School of Forestry converted a war surplus crash truck for fire control on the school forest. This unit was originally designed for use with foam or fog to combat aircraft fires on landing strips. It is equipped with a 100-hp. gasoline engine connected directly to a 3-inch high-pressure centrifugal pump capable of pumping 200 gallons per minute at 150 pounds pressure. The 6 x 6 all-wheel drive can handle the load under most conditions easily.

The conversion consisted of removing all excess gear not necessary for forest fire control and increasing tank capacity from 800 to 1,200 gallons. All foam equipment was removed because it was impractical for our conditions; the foam nozzles on the main gun were replaced by two $\frac{5}{8}$ -inch solid stream nozzles. There are two 2 $\frac{1}{2}$ -inch and/or two 1 $\frac{1}{2}$ -inch standard hose outlets on the sides and rear of the machine. The most useful and convenient outlet is the large gun on top of the unit with a $\frac{3}{16}$ -inch fog nozzle and two $\frac{5}{8}$ -inch solid stream nozzles. A man standing on a platform on top of the unit controls the gun with a pair of handlebars. He can change from fog to solid stream parallel nozzles by flipping a single lever (fig. 1).



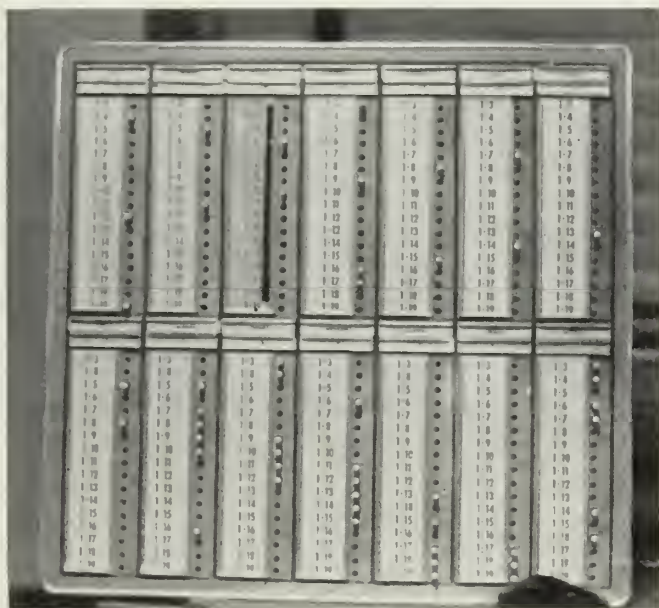
FIGURE 1.—Unit with fog nozzle at maximum capacity of 150 g. p. m. at 150 p. s. i.; the water has hurricane force at 25 to 30 feet with a maximum range of 50 feet. The solid stream at maximum capacity of 200 g. p. m. at 150 p. s. i. with twin $\frac{5}{8}$ -inch nozzles has a range of 80 to 90 feet.

The unit works very well on direct attack but its greatest advantage comes when used for wetting down the side of a fireline or road opposite a backfire where sparkovers can be common during dry, windy weather. It will thoroughly soak a strip 30 to 40 feet wide for $\frac{1}{4}$ to $\frac{1}{2}$ mile, depending on the amount of fuel. The use of a suitable wetting agent is highly recommended as this increases the efficiency of the water tremendously. The unit is equipped with an exhaust primer which can fill the tank in less than 1 minute from a suitable supply of water.



Personnel Scheduled Pass and Leave Chart Board

Quick action may be required at any place in this five-county district. The chart board tells district supervisors, radio dispatcher, and office personnel at a glance which of the 17 conservation officers are on duty that day or any day during the 2-week pay period. Colored $\frac{1}{4}$ -inch dowel pins show the officers *not on duty* because of pass days, compensatory time, annual or sick leave. No pin indicates officer is on duty. The board is posted at the beginning of each period and kept current. A movable red plastic strip mounted vertically indicates the day of the week.



The board is $\frac{3}{4}$ -inch plywood, 23 by 23 inches, edged with chrome molding. It is divided into two sections (weeks) of 7 days each. Beneath each day are the radio call numbers of each patrol car (officer) with a $\frac{1}{4}$ -inch hole, drilled $\frac{1}{2}$ -inch deep, beside each number to hold a dowel pin as needed.—JOHN J. MARNICH, *Office Manager, Baraga District, Michigan Department of Conservation.*

TILT-BED TRACTOR TRANSPORT

WILLARD J. VOGEL

*Fire Control Officer, Yakima Indian Reservation
Bureau of Indian Affairs*

The Yakima Indian Reservation on the east slopes of the Cascade Mountains in Washington has an area of approximately 500,000 acres of timber and 525,000 acres of grass and brush land that requires intensive protection against fire. The reservation is roughly 50 miles wide and 70 miles long with most of the areas requiring protection containing only substandard roads. Transporting of tractor equipment in the past has posed many problems with slowness of delivery to the fire being the most serious.

Because of the arid conditions and heavy, flammable growth present on the reservation, speed in placing suitable first-attack equipment on a fire becomes a must. Transportation of this equipment by means of a semitrailer or a low-boy is impractical because of steep, narrow, twisting roads, particularly in the back country. For this reason, it was decided to purchase a heavy truck and to construct on it a tilt-bed body originally developed by the State of California, Department of Resources, Division of Forestry (fig. 1).

The truck used is rated at 35,000 GVW with the frame modified to the exact dimensions of CA 110" and CEF 147½. The tandem-drive rear axles are straight-line-drive to provide clearance for a cylinder on each side of the propeller shaft. The transmission is 5 speed with an auxiliary 3 speed. The large 406-cubic-inch engine and the many available gear ratios enable the truck to transport our OC-12 tractor with dozer at speeds of 50 to 55 m. p. h. on highways and to maintain satisfactory speeds on all the various grades encountered. Since the truck operates over both heavily traveled highways and back mountain roads where handling ease and safety are essential, it is equipped with power steering and air-over-hydraulic brakes. We consider it essential that heavy trucks to be operated in such rough country be equipped with power steering.

The tilt-bed body, which has a capacity of 19,000 pounds, hinges just ahead of the rear set of drivers. Two systems, one hydraulic and one air, control operation of the bed. The air system is used only to raise or lower the bed empty and is controlled by a three-way valve in the cab. The hydraulic system is merely a hydraulic cushioning cylinder that determines the speed at which the bed will tilt or lower with the tractor. The hydraulic cylinder is controlled by a globe valve requiring only an initial adjustment at the beginning of the season. The bed is locked in running position by an automatic safety lock.

To unload the tractor, it is necessary to release the safety lock, back the tractor until its weight tilts the bed and then back down the ramp (fig. 2). The bed will stay in the raised position until the tractor is reloaded or, if desired, the bed can be lowered with the air control. Chock blocks set in stakepockets at the front



FIGURE 1.—Tilt-bed tractor transport.



FIGURE 2.—Truck bed in loading or unloading position.

of the tread runway prevent the dozer blade from striking the back of the cab. These also enable positioning of the tractor in such manner that weight is properly distributed.

Experience during the 1957 fire season indicated no need for modification of the unit, although practically all conditions were encountered in transporting the heavy tractor dozer equipment. Because of the tilt-bed it is not necessary to waste time in picking an unloading site and the tractor can be quickly unloaded by one man. When necessary to change the tractor's location on a fireline, it is often quicker to reload and move by the tilt-bed truck rather than by "walking" the tractor. It is felt that with a heavier truck this type of bed would be suitable for transporting tractors that are larger than the OC-12, D-4, or TD-9 class.

A TRAINING COURSE IN PRINCIPLES OF ORGANIZATION FOR FIRE SUPPRESSION

Region 7, Division of Fire Control, U. S. Forest Service

In the Eastern Region, comprising 14 States from Kentucky, West Virginia and Virginia, northeast through Maine, opportunities for developing skills in organizing large fire suppression forces are limited. There are numerous fast-spreading and dangerous forest fires most years, but these are controlled within hours by well-seasoned small crews. Campaign fires requiring large forces occur only rarely during the critical years. Ten years may pass before the skill of a fire control man in mobilizing and managing a large fire organization is put to a test. Some young firemen have never seen a large fire organization in action.

For these reasons, the Regional Fire Training Committee set out to perfect a fire organization training course that would meet needs peculiar to this region. Their desire was to make full use of available excellent handbook information and to stay out of the old wheel tracks of previous training courses by organizing and developing a new approach.

The scope of the task was narrowed by focusing on three key items for the 1957 training program. A lesson plan was developed for each item; a test training session was run; the results of the test were evaluated and revisions made as required. The committee used this restricted approach to pay respect to the training principle of "one thing at a time." It answered the question of what was basic and why, and set up a standard of proficiency expected of trainees for each key item.

Lesson one had for its subject "Principles of Organization." The command, plans, service, and line functions were explained in a series of organizational setups beginning with a 2-man fire and proceeding through a 3-sector fire. Charts were used as training aids. This is about as exciting as a multiplication drill to a school-boy, but the test training run established the soundness of this approach; namely, that specific knowledge of organization principles must be a part of the trainee's equipment. He is not ready for the steps ahead until he has become grounded in the principles. The textbook used for this subject was "Principles of Organization for Forest Fire Suppression," 1953.

The next step in the training process was the application of principles of organization. The subject of "recruiting, training, and maintaining in a state of readiness the organizational forces planned for a protection unit" was covered in Lesson No. 2. For this, the demonstration method of instruction was used. A three-sector fire organization was set up for a particular district. Live organization charts were built up from a form devised for this purpose. The details of size of an organization required, where it will come from, and other considerations vary by protection units, but the basic principle does not change. Lessons No. 1 and 2 are required to prepare the trainee for the next stage of instruction, the application of principles to a specific suppression problem.

In Lesson No. 3, the operational procedures of a fire headquarters in the suppression of a specific fire were demonstrated.

Before the demonstration, the trainees were briefed in the following: (1) the geographical location of the fire, the topographic features and fuel of the fire area; (2) the fire weather preceding and leading up to the fire; (3) a sequence of events from time of discovery up to time fire boss gets on the fire.

Special props were used for briefing and for the demonstration that followed. One end of a ranger warehouse provided the required classroom space, a space for a fire headquarters setup, and a relief model of the part of the ranger district on which the fire occurred. The fire headquarters was furnished with a table, chairs, 2 bulletin boards each 4 by 8 feet for display of easel-sized (27 by 36-inch) charts. To one side of the fire headquarters and in front of the trainees was a relief model of the fire area.

The model was made out of $1\frac{1}{2}$ cubic yards of sawdust and shaped to bring out the main mountain ranges, prominent spur ridges, and drainages, to approximate features of the actual fire area. The fire edge was shown by a red paper ribbon with sector locations plainly marked. Topographic and operational features were identified on the model by a small cardboard poster secured in a cleft of a twig stuck in the sawdust. Another important prop was a chart that showed the sequence of events from the time the fire was discovered until the fire boss got to it.

The props added a touch of realism that gave the trainees a feeling of looking in on the entire situation. Most important, the props helped them to arrive at a common understanding of the problem. Since the trainees had in the previous lesson worked on the organizational setup for the protection unit, their background included this information. Trainees were instructed to disregard all tactical considerations and concentrate on organization. The presentation up to this point could be summed up in these words "Here is the problem."

The next phase, the actual demonstration, in effect said, "Here is how we handled it." The demonstration was built around the acceptance of responsibility of the fire boss for the fire, his preliminary analysis of the problem, and how he assembled a staff for plans, service, and line functions; also, how the fire suppression plans were made and executed through the headquarters staff. This demonstration was made by the fire boss as he explained the action he took from the time he received the report of the fire.

Demonstration of functional responsibility of staff members through discussion and with the help of charts made clear staff responsibilities. Staff work was demonstrated by the use of skits that were carefully prepared and rehearsed prior to the demonstration. No attempt was made to recite lines, but the essential action was acted out in a natural manner. The demonstration was climaxed in a planning and strategy meeting of the fire boss with his staff.

The following organization fundamentals were emphasized:

1. Decision making by the fire boss, including his initial decision that as fire boss he is responsible for aggressive suppression action.

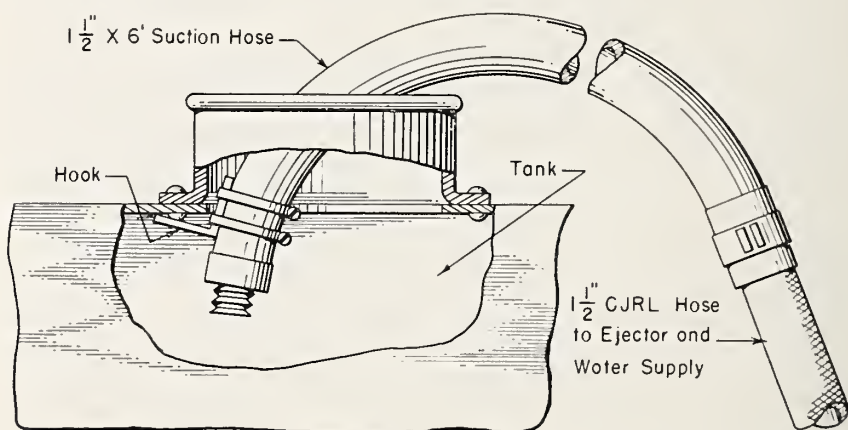
2. Mobilization requirements as met by the fire boss.
3. The initial estimate of a job and the aggressive action to get staff appointed, briefed, and at work. (In deference to the "one thing at a time" principle of training, instruction was limited to fire headquarters operations.)
4. Operations based on full consideration of fire weather and special fire forecasts.
5. Safety predicated on natural hazards and the effect of fire weather.
6. Operations conducted on a timetable basis that require proper coordination of planning and execution of plans and service.
7. Fire boss exercises his command function through a fire staff.

The task of developing competent organizers to function on an occasional big fire is complicated and difficult. Training methods must be expert if they are to offset the lack of actual practice and experience of the trainee. The 1957 regional test training session was favorably received by the trainee group of rangers and staff men.



Improved Ejector Drafting

We have experienced difficulty in drafting water into a demountable fire tanker because the cotton-jacket hose to the ejector kinks when it is bent into the filler-cap opening. The kink results in an uneven flow of water, and it has been necessary for a man to be in attendance at the filling to see that the hose doesn't slip out. Both of these problems have been solved by substituting a length of 1½-inch suction hose for the final length of hose into the tank and using a wire hook to hold it in place.



The release of the services of the man at filler-cap opening can be very important where drafting and discharging to hose lines are being done simultaneously. Most slip-on fire tankers are already equipped with the 1½-inch suction hose, but the addition of the wire hook would be beneficial. —RAYMOND E. JUAREZ, *Fire Control Aid, Shasta-Trinity National Forests.*

AIRCRAFT USE IN MISSOURI

OSAL B. CAPPS

Chief of Fire Control, Missouri Conservation Commission

The Missouri Conservation Commission uses aircraft for administration, waterfowl and game surveys, law enforcement, forest land inspection, forest fire control, and many related activities. It acquired its first airplane in 1946, a war surplus L-5. Three years later this unit was replaced by a Stinson station wagon that was used for all activities until 1954 and then replaced by a Cessna 180. The Cessna 180 is still in service. A Piper PA-18 was also purchased in 1954 and assigned directly to a fire control district that has a large acreage of State-owned land. This particular district had been plagued each year with incendiary fires.

Full-time pilots are employed to operate and maintain the two State-owned airplanes, and when not engaged in these duties they are assigned other work. Direct operating costs amount to \$6.50 an hour for the Cessna 180 and \$5.50 an hour for the Piper PA-18. This includes gas, oil, maintenance, overhaul, and miscellaneous expenses, but not the pilot's salaries, insurance, hangar, depreciation, etc.

Each of the 10 fire control districts is authorized and encouraged to lease aircraft from private operators within their district or close by, either with or without pilots, as needed. The State-owned Cessna 180 can also be obtained when urgently needed to supplement district aircraft. Types of aircraft leased have been the Cessna 140, Aeronca 7 AC, Aeronca 7 BC, Piper Tripacer, etc.

The rate per hour for leased aircraft, including all flying time, was raised from \$9.25 to \$10.00 in 1957. Some operators with much experience are paid \$10.75. We are paying \$15.00 per hour for a Piper Tripacer, 150 hp., which is used on an experimental basis for night work. An aircraft and operator on standby costs \$2.50 per hour. Standby time is limited and is normally not authorized at the home base of the airplane.

Radio equipment is installed in the leased aircraft by State radio technicians. Army surplus SCR-610 equipment has been used in the past but transistorized commercial-type equipment is now being installed. State-owned aircraft have multifrequency radio equipment.

Detection.—Fire control aircraft are used to supplement detection work of towers on days when visibility is limited and/or when fire danger is high. Also, they are used for detection when a towerman is off the tower fighting fires. The pilot of the airplane acts as observer; he uses a State highway map with a scale of one-half inch to the mile to report fires to a dispatcher by section, township, and range. Topographic maps are also used for this purpose.

Suppression.—The pilot scouts a fire and gives the fire crew leader such information as size, fuel, topography, rate of spread, critical areas, men or equipment already on fire, possible cause, and the best place to start fighting the fire. On large fires the fire boss relies on the pilot to keep him informed of breakovers, backfires, wind changes, potential danger areas, etc. (fig. 1). The district forester checks on a large fire by air as soon as possible after it is reported and quickly determines what steps should be taken to bring it under control and whether reserve manpower or equipment should be dispatched. Aircraft are often used to direct fire crews to fires in isolated spots. Large fires are patrolled and mapped from the air, and small fires are checked several times a day after they are suppressed if there is danger of breakovers.

Prevention.—Quick checking of fires materially reduces incendiary action during daylight hours. The point of origin of a fire can be rather accurately determined from the air. This is an important factor in law enforcement (fig. 2). During the past few years, aircraft and ground personnel working together have caught several men who set incendiary fires. Experimental work



FIGURE 1.—Aircraft provide the fire boss with information he needs on a fire like this one.



FIGURE 2.—Aircraft are effective in fire-law enforcement.

was done last year to determine whether the use of aircraft at night would be effective in reducing incendiary fires started under cover of darkness. The results were promising and the experiment will be continued this year.

Although airplanes have an undisputed place, helicopters are probably the coming thing in fire control work in Missouri. In areas where there are small clearings, they would be ideal for getting a small, initial attack crew on a fire. The helicopter could be used for both detection and suppression, and it would be very effective in fire-law enforcement. Helicopters are used for the latter purpose on a large military reservation in our forested area, Fort Leonard Wood. We have been able to use these on adjacent areas in order to get an idea of their value. Although the cost per hour seems excessive, there is no doubt that the helicopter is a very versatile fire control tool.

THE AIR TANKER AS AN INITIAL ATTACK TOOL

GEORGE E. LAFFERTY

Fire Control Officer, Boise National Forest

The use of air tankers as an aid in the control of wildfire has been increasing year by year. Although much has been written about their use in combating large, uncontrolled fires, little has been written about their use as an initial attack tool.

During the 1957 fire season the Boise National Forest experimented with air tankers and chemicals for initial attack. A contract Ford Tri-motor airplane (fig. 1) rigged for aerial spraying was converted to an air tanker by the addition of 19- by 20-inch free-swinging gates to the bottoms of the spray tanks. The aircraft carried two 275-gallon tanks in tandem. Cable releases permitted emptying one tank at a time or both at once. Five hundred gallons of water-suspended sodium calcium borate was normally carried in the two tanks. This water and chemical slurry weighed approximately 10 pounds per gallon, making the total cargo exceed 5,000 pounds.

Calibration tests showed a drop pattern roughly 70 feet wide and 700 feet long when both tanks were emptied at an altitude of 50 feet. Concentrations as heavy as 6 gallons per 100 square feet were measured in the drop pattern. The entire load could be discharged within 7 seconds.



FIGURE 1.—Ford Tri-motor air tanker.

In addition to 50 drops on large project fires, 24 "borate" drops were made on 13 small fires (table 1). The results were beyond expectations. We know that part of the success was due to the skill of operator-pilot Glenn Higby. His experience includes hundreds of hours of mountain flying in aerial spraying and paracargo operations. The aircraft itself seems to be especially adapted to the dropping of liquids in steep and rugged mountains. While it is relatively slow (airspeed 100 m. p. h.) compared to modern aircraft, this deficiency is offset by its maneuverability and accuracy.

TABLE 1.—*Use of air tankers, Boise National Forest, 1957*

Name of fire	Drops	Flying time	Cost ¹	Result		
				Assured control	Helped control	No value
	Number	Hours	Dollars			
Warm Spring Creek	4	5.3	1,250	X	..	..
Louse Creek	1	1.2	300	X	..	..
Lincoln Creek	2	1.4	500	X	..	..
Pine Creek	2	2.4	600	..	X	..
Golden Age	1	.8	260	..	..	X
Profile Creek	2	4.5	820	X	..	..
Middle Fork	2	2.2	580	X	..	..
Sheep Corral	1	.7	250	X	..	..
Peace Rock	1	1.2	300	..	..	X
Blue Moon	1	1.7	350	..	..	X
Whitehawk	1	1.2	300	..	..	X
Fullmoon	5	5.6	1,220	X	..	..
Mineral Creek	1	1.1	290	..	X	..
Total	24	29.3	7,020	7	2	4

¹Cost includes procurement, flying time, labor, and equipment purchase or rentals.

Part of the effectiveness of the tanker as an initial attack tool depends on both it and the pilot being in a constant standby status during daylight hours. Procedures were established that permitted takeoff 15 minutes following "scramble" orders.

The effectiveness of air-delivered chemicals is highly dependent upon the accuracy and location of the drop. A lack of trained personnel on a fire will usually necessitate making tactical decisions from the air. There are two solutions to this problem. One is to have a fire-behavior specialist in the air tanker or in a radio-equipped spotter airplane to direct operations. The second requires that the pilot of the air tanker be adequately trained in fire behavior and in suppression tactics so that he can make proper applications without guidance. The latter solution would minimize loss of time and eliminate the chance for complete failure in event of communication trouble.

The principal value of sodium calcium borate is in retarding the spread of a fire for a sufficient time to permit suppression forces to effect control. This is of the utmost importance during periods of extreme fire danger. Air tankers were used in conjunction with action by both ground forces and smokejumpers,

and with notable success. The program can be credited with being directly responsible for the control of 7 threatening fires. These fires started during periods of high fire danger and the rapidity with which they spread indicated serious control problems.

Other reports testify to the air tanker's success as an initial attack tool. The Payette National Forest's fire staff officer had this to say after investigating a fire we first attacked with chemicals: "The Profile Creek fire was discovered at 1315 on August 17. Fuel moisture percent was 4. For the following 4 days the fuel moisture percent remained at 4. The fire originated in the bottom of a canyon and had 3 miles of heavy fuels on moderate to steep slopes ahead of the fire.

"As soon as the fire was reported, smokejumpers were dispatched from Idaho City and a Ford load of borate from Boise. When the jumpers arrived it was too windy to jump so they returned to Idaho City. The load of borate was dropped across the lead of the fire and the plane returned for another load. . . 50 men reached the fire by 1600. . . Ranger Dahlgreen reported that if it hadn't been for the borate drop, the personnel on the fire could not have held it that day. The borate held the fire from spreading uphill until the ground personnel and jumpers arrived. Considering the burning conditions and fuel available for the fire to spread in, the borate undoubtedly prevented a large project fire."

Ranger Jim Butler of the Mountain Home District, Boise National Forest, reported, "The Lincoln Creek fire started on August 16, in medium slash and had burned an area between 2 and 3 acres in size. . . the Ford came over as it was crowning and very effectively downed the fire. The first load cut the fire down to where direct close attack on the lead was possible."

Another experience was reported by Ranger Butler as follows: "The Ford was on this fire immediately and hit the head of the fire with a load of slurry that really flattened it. Without this help, considering the 30 m. p. h. wind which prevailed, we would have been unable to control it at the 2 or 3 acres it burned."

Ranger Jack Wilcock of the Bear Valley District, Boise National Forest, in reporting the Warm Spring Creek fire writes, "I conclude from observing the progress of the fire from the air and on the ground that the water and chemicals stopped the spread of the fire in the light fuels and kept the fire on the ground in heavy fuels. I believe this potentially dangerous fire was kept to an area of 2 acres by the use of this new tool."

Since protection dollars are normally fixed, initiating a new method or piece of equipment requires a shift in present organizations. The cost of adding a standby air tanker is reflected in reduced crews or other equipment. Realizing this, we still feel that the air tanker has proved itself. Our confidence in the use of "borate" in the initial attack is such that we plan to have a standby air tanker in 1958.

WATER DROPPING FROM SEAPLANES ON THE SUPERIOR NATIONAL FOREST

L. J. MC DONALD, *Superintendent, Ely Service Center,*
and W. J. EMERSON, *Assistant Supervisor*

A new and unique type of water dropping on fires is being worked out on the Superior National Forest in the wilderness-lakes country of northern Minnesota. Seaplanes operating out of Ely, Minn., on fire control missions are now equipped to pick up water from lake surfaces while taxiing on the takeoff run, then take to the air and cascade the water onto forest fires.

The 3-million-acre Superior Forest, with its many lakes and inaccessible Boundary Waters Canoe Area, is ideally suited to this kind of fire fighting (fig. 1). Successfully directed water dropping



FIGURE 1.—Seaplane on fire control mission over Boundary Waters Canoe Area of Superior National Forest.

missions may serve as a holding action on remote forest fires and give ground forces the time they need to get to the fire and apply control measures. Although the project is still in an experimental stage, the mechanical problems of picking up and dropping the water are essentially solved, and the main problems remaining are those of skillful application. Because the development of these procedures was completed late in the 1957 fire season, they have not been tried on actual fires.

Water dropping from seaplanes on the Superior Forest was an outgrowth of the fish-dropping technique that was successfully developed several years ago. Fish-stocking operations are carried

on by flying over remote, inaccessible lakes and cascading a load of water and fingerlings, or fry, into the lake from a fish-dropping hopper installed in the cargo-dropping hatch. The 40-gallon fish hopper provided the means of experimenting with water dropping on fires, but the volume of water was too small for an effective fire-suppression operation.

A 125-gallon water tank with baffles was constructed of aluminum, with a round opening in the bottom (fig. 2). It fits into the 17-inch circular hatch of the plane and can be installed quickly and easily through the side door of the plane when requests for water dropping are received. A quick-opening, gate-type release permits cascading the full volume of water from the plane in a very few seconds. The water-cascading release mechanism is operated by one man sitting in the co-pilot's position. Advice on the accuracy of each drop can be received by the pilot and bombardier from radio-equipped groundmen.

The airplane used in the initial experimental and development work was a Noorduyn-Norseman. This was replaced recently with a DeHavilland Beaver. Pickup and dropping equipment have been modified to fit the latter airplane.

Test drops during the past season indicated that the water pattern, when it hits the ground, is about 300 feet long and 50 feet wide, averaging about .01 inch of "rainfall." Since these tests were in the open, others are planned to determine the influence of trees and vegetation on the effectiveness of the operation. Also planned for this season are dropping experiments with



FIGURE 2.—View of bottom of 125-gallon water tank showing outlet and release gate at left and water pickup tube at right.



FIGURE 3.—Side view of DeHavilland Beaver Seaplane showing water pickup tube extending from tank inside plane through hole in false door. Square hole just left of tube is tank overflow tube.

the addition of detergents of various types and borates. These drops will be applied to slash-burning projects and other test fires.

While a single drop of 125 gallons of water on most fires is not expected to have a very marked effect, repeated drops in a relatively short time should have. Such drops are possible because of the water pickup device. The pickup consists of a piece of airplane strut that is connected to the water tank through an opening in the fuselage (fig. 3). The lower end of the tube rests just above the surface of the lake when the seaplane is stopped.

As the plane makes its takeoff run, the pontoons assume a position parallel with the lake surface. This brings the end of the water pickup tube down into the water and the tank is filled in about 15 seconds (fig. 4). An overflow vent from the tank throws excess water out the side of the plane as soon as the tank is filled. The seaplane then lifts from the lake and proceeds to the fire.

The large number of lakes scattered throughout the Superior National Forest make it possible for a seaplane to pick up water within relatively close range of any fire that may occur. With



FIGURE 4.—Seaplane picking up water for a fire drop.

only a few minutes flying time involved between pickup and drop in most areas, it is estimated that by repeated drops sufficient moisture can be cascaded onto a fire in the early stages to hold it and keep it from "taking off" into inaccessible areas until ground forces arrive. Even when a suppression force is working on a fire, repeated water drops on spot fires and hot spots should help to take some of the pressure off the fire fighters and to insure that the fire does not crown and get out of control.



Nozzle Guard For Jack Pumps

The common jack pump used on the 5-gallon back-pack can or water bag will usually break where the spray attachment joins the handle whenever it is dropped. This can easily be prevented by installing an inexpensive guard made of a one-half inch washer, a 2-inch steel ring of one-eighth inch material, and 9 inches of one-eighth inch steel rod. The steel rod is cut into 3-inch struts which are spaced equidistant and welded in place between the



ring and the washer. The guard is readily installed by removing the pump spray nozzle and inserting the one-half inch washer over the threaded end of the pump handle. Spray adjustment of the nozzle can be made by using the index finger between any two struts on the guard.—GEOFFREY E. GREENE, *District Ranger, Helena National Forest.*

INFORMATION FOR CONTRIBUTORS

It is requested that all contributions be submitted in duplicate, typed double space, and with no paragraphs breaking over to the next page.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and unit.

Any introductory or explanatory information should not be included in the body of the article, but should be stated in the letter of transmittal.

Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints are acceptable. Legends for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the legend being separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the type page proportions in mind, and lettered so as to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands. *Paper clips should never be used.*

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India ink line drawings will reproduce properly, but no prints (black-line prints or blueprints) will give clear reproductions. Please therefore submit well-drawn tracings instead of prints.



**Smokeys
Commandments**

**BREAK MATCHES
CRUSH SMOKES
BE SURE ALL
FIRES ARE OUT!**

*Remember—
Only you can
**PREVENT
FOREST FIRES!***



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FIRE CONTROL NOTES

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A PERIODICAL DEVOTED
TO THE TECHNIQUE OF
FOREST FIRE CONTROL

FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.

FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

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Forest Service, Washington, D. C.

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CONTROL OF AIRCRAFT ON FOREST FIRES

CARL C. WILSON

Forester, California Forest and Range Experiment Station¹

[The many new uses of aircraft in fire fighting have posed numerous problems in organizing air operations. This article describes the functions that are necessary for a safe operation and suggests one way of fitting them into the conventional fire fighting organization. This plan has not been adopted as the standard organization by the Forest Service.—Ed.]

If you have flown by commercial airline recently, you must be aware of the elaborate precautions taken to assure that each plane arrives safely and on schedule at its destination. Few controls were needed when Lindbergh made his historic flight, but today major airports are beehives of traffic and rigid air traffic control is essential.

When the first air patrol was organized in California, few rangers could foresee that air traffic over forest fires would ever be a critical problem; today air attack² has come of age and airplanes are commonplace over our forests. In 1957 air tankers dropped water and fire retardant chemicals on 101 forest and brush fires, and helicopters delivered specially trained fire fighters to 42 small fires.

DEVELOPMENT OF AIR ATTACK

The breakthrough in fire fighting techniques involving aircraft probably began in 1919 when Regional Forester Coert duBoise and Major "Hap" Arnold organized a regular patrol for the west side of the Sierra Nevada. It may have started in the early 1920's when serious thought was first given to fighting fire by dropping water from aircraft. It was given a big boost in 1936 when extensive aerial bombing experiments were conducted in California by the Forest Service.

We like to think that modern air attack began during Operation Firestop in 1954 when all sorts of new tools, methods, and techniques were studied in southern California. During this 1-year crash program, helicopters were used to lay fire hose, carry helitanks, and fan backfires. A torpedo bomber dropped 600 gallons of water from its bomb bay on a test fire.

Then in 1955 the Mendocino National Forest demonstrated that a low-flying crop-duster plane could carry and drop as much as 120 gallons of water at a time. Trials on wildfires showed the air tanker could be helpful to the ground forces.

¹Maintained at Berkeley, Calif., by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of California.

This report is made in collaboration with the California Air Attack Executive Committee. The committee coordinates air attack research and development in California. Representatives are from the California Division of Forestry, and from Region 5, Arcadia Equipment Development Center, and California Forest and Range Experiment Station of the U. S. Forest Service.

²Tactical air support for ground forest fire fighters.

These trials were so promising that in 1956 a fleet of 7 agricultural-type airplanes became part of the California fire fighting force. These planes fought 25 fires from the Oregon border to the Mexican border by cascading sodium calcium borate and plain water through the dump valve in the bottom of their tanks. Air support was a deciding factor in assuring control of 15 of the 25 fires and was a definite help to ground forces on 5 others.

OPERATIONAL DIFFICULTIES GROW

But operational problems showed up. Air traffic was hard to control, and it was difficult to coordinate the air arm with the ground forces. These problems were magnified on large fires. For example, air traffic control was extremely difficult on the 10,250-acre McKinley Fire on the San Bernardino National Forest in 1956. In addition to the 7-plane air tanker squad, 1 experimental TBM air tanker, a reconnaissance plane, several cargo ships, 2 helicopters, and many sightseeing craft were over the fire area.

Near misses occurred in the smoke. Scouts in helicopters often were forced to stay on the ground while the air tankers were making drops. Condensation trails from jets blended with the smoke from the fire. An overtaxed fire organization was burdened by the problems of air traffic control, and local forest communication channels were jammed. Fortunately, no air crashes occurred.

As the 1956 season progressed it became more and more apparent that aircraft, like any other specialized fire tool, have to be closely coordinated with other fireline action. When an air tanker attacks a fire, for example, its effectiveness depends on timing and accuracy, and this can be assured only if there are good air-to-ground and ground-to-air communications. The speed of these aircraft further emphasizes the need for careful control.

CONTROL NEEDS ANALYZED

In February 1957 specialists in ground fire fighting, aircraft, and organization met at the California Forest and Range Experiment Station to plan an organizational pattern for use on fires where there is tactical air support. First, all of the useful air functions that can be performed by long-range transport, short-range transport, attack, and reconnaissance types of aircraft were summarized and classified. Next, present aircraft capabilities were listed for all commercial models, both fixed-wing and rotary-wing craft, that are used or might logically be used by fire agencies in California. These categories were separated by the four types of aircraft already classified.

Fire situations were then classified in terms of changing aircraft requirements. These situations included pre-fire and fire-detection reconnaissance, and Class A and B, Class C and D, Class E, and multiple fires.

The most important part of the analysis job came next, i. e., determining the method of control for particular air operations. Each fire situation was built up from the simple detection needs after a lightning fire to the Class E fire conceivably involving

fixed-wing ships to deliver smokejumpers, make cargo drops, and serve as air tankers; and helicopters for reconnaissance, laying hose, dropping water, and delivering helipumpers and manpower.

NEW ORGANIZATION SUGGESTED

After the aircraft requirements and control problems for each fire situation were reviewed, it was evident that special control jobs had to be performed in each situation. For example, a man was needed to direct aircraft operations on each air mission and on each fire. On a large fire this man might serve under the direct supervision of the fire boss with close liaison with the plans, service, and line units. On small fires the fire boss logically could handle this job.

The primary assignment of this man would be to maintain direct control of all aircraft movements and supervise the officers who direct the airports or heliports within the immediate fire area. He would inform the fire dispatcher of the aircraft needed for missions ordered by the fire boss and maintain records and reports as required. The man chosen for this job should be familiar with the capabilities and limitations of all aircraft used and by all means should be well trained in fire fighting. This proposed assistant to the fire boss would be called an "Air Control Chief."

It was also evident that a man was needed to direct air operations at a specific airport or heliport—a job usually handled in the Forest Service by an Air Operations Officer. This man would orient and brief ground and flight crews and maintain all necessary records. At a commercial airport he maintains liaison with the airport manager. Officers in this job outside of a fire area ordinarily report directly to the central dispatcher. Inside the fire area they report to the Air Control Chief. This man would be called an "Air Traffic Manager."

It was agreed that an "Air Unit Leader" should be selected when two or more aircraft of the same type are assigned to a specific mission. (In California we have used a reconnaissance ship to direct each air tanker to its target. This plane is called the "Bird Dog," and the pilot and his passenger function as the Air Unit Leader.) In or near an airport or heliport this man would report to the Air Traffic Manager. In the fire area he would report to the Air Control Chief.

The interrelationship of these proposed positions and the established fire organization is shown in figure 1.³

PROPOSALS APPRAISED

The proposed organizational pattern was reviewed by representatives of the major California fire agencies, the California Forest and Range Experiment Station, and the Washington Office of the Forest Service, and was approved for field testing during

³To assure that these proposed air control jobs function smoothly, the need for good radio communications is emphasized. Often a separate air net will be required.

INTEGRATING AIR OPERATIONS INTO CONVENTIONAL FIRE ORGANIZATION

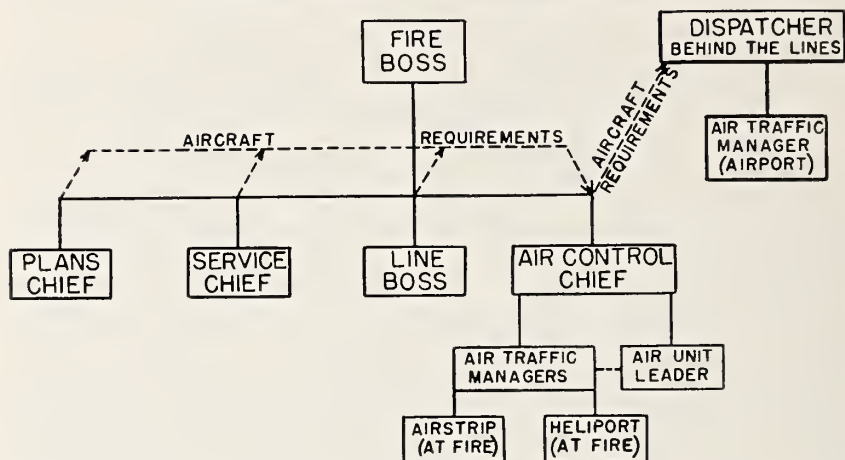


FIGURE 1.—How the suggested air operations positions fit into conventional large-fire organization. The solid lines indicate the direct command relationship in a fire operation. The dash lines show coordinating or advisory relationships. This proposed organization for air operation in fire fighting was field tested in California in 1957.

the 1957 fire season. Reports from the field indicate that there were numerous breakdowns in carrying the plan out. Lack of trained forest officers to fill the new air control positions and inadequate radio communications were the main reasons.

On the other hand, there were reports to show that a well-planned air control organization produces excellent results. One such report by experiment station employee James Murphy demonstrates how such an organization was used effectively on the Angeles National Forest.

"The air arm consisted of 7 air tankers, a 'Bird Dog' plane, and 3 helicopters. The air tankers and 'Bird Dog' were operating out of the Palmdale Airport about 10 miles from the fire. The helicopters used a base heliport near the main fire camp. The situation was critical because there was another major fire on the forest, and some of the aircraft were shuttling back and forth to it. The fire boss assigned an assistant ranger to the Air Traffic Manager job at Palmdale; the Helitack foreman to the Air Traffic Manager job at the nearby heliport; and I became the Air Control Chief. The 'Bird Dog' pilot functioned as Air Unit Leader for the air tankers.

"Here's how we operated: When an air tanker drop was needed on a particular section of line, the fire boss requested the drop through me and gave the location by sector number. I relayed the request to the Air Traffic Manager at the airport, and he assigned the air tankers to the mission. The Air Unit Leader

led the ships to the fire. As soon as the tankers were airborne, I asked the heliport Air Traffic Manager to ground the helicopters operating in the drop sector. When the Air Unit Leader and the tankers arrived in the drop area, I notified the Division or Line Boss in that area and he worked closely with the Air Unit Leader in getting the drops where he wanted them.

"When the last tanker made his drop, the Air Unit Leader reported to me (Air Control Chief), and the tankers were cleared to return to the airport. I then notified the base heliport that they could resume operations. It sounds complicated, but it isn't if the communications system operates well. If it doesn't, the safety record can go sour in a hurry."

We know, of course, that the safe way is the most efficient way to fight forest fires. As ground fire equipment became more specialized, we recognized the need for specially trained men to supervise new tools. Cat bosses and pumper bosses are common on most big fires now. On the other hand, we have been slow to see the need for special personnel to direct our new system of air attack. Strict air traffic control is mandatory if we expect to have safe and effective air operations on forest fires. Safety and efficiency are functions of coordination, and coordination is possible only with adequate communications.

AIRCRAFT SUPPORT OF FIRE CONTROL IN NORTH CAROLINA

R. C. WINKWORTH

*Regional Forester, Division of Forestry, North Carolina
Department of Conservation and Development*

The North Carolina Division of Forestry now owns and operates a small but highly efficient fleet of three liaison type aircraft for fire control purposes. This vital support unit has evolved during the past 9 years from a beginning when field fire control men attempted to satisfy the obvious need for air scouting by authorized use of local aircraft and pilots. Present operations are under established policy which includes planned expansion for the future. This article summarizes lessons learned during this period of development and outlines current thinking on the future use of aircraft in this southeastern State.

At present, air support is used in the presuppression jobs of detection and smokechasing and in several prevention jobs, including fire investigation and law enforcement. In suppression, planes are used for long- and short-range transportation of material and personnel, logistic support of remote ground crews, and scouting. Direct attack is in the experimental stage. Because of the number of large fires, the suppression values of the existing fleet far outweigh those of prevention and presuppression. In the inaccessible areas, particularly of the Atlantic Coastal Plain, scouting service alone more than justifies all costs.

PRESUPPRESSION AND PREVENTION

Detection from airplanes has proved to be a supplement but not a substitute for detection from towers. The critical factor in successful use of aircraft for various types of patrol service is the fact that the degree of intensity required sharply limits the size of the patrol area that can be covered. This ratio of intensity to area depends upon local conditions and must be established by local experience. For example, use of a patrol plane in high occurrence areas, or where brush and field burning is prevalent, must be restricted to a relatively small area because of time lost in locating and investigating the numerous smokes. Regular use of aircraft in lieu of a group of towers during periods of marginal danger, such as at the beginning or end of fire season, appears to have doubtful economic value in the big woods areas of the coastal plain region. Cost studies showed other parts of the State to be more promising. In contrast, aircraft patrol in specific high-hazard areas following dry thunderstorms and during periods of limited visibility has been highly successful.

Use of a plane to supplement smokechasers in "hot" areas during critical periods has also been of extreme value. By taking station between two or more primary towers, the pilot is able to monitor tower radio traffic. He can pinpoint smokes, identify wildfires, and determine best means of access almost before the smokechaser has time to leave his station. Smokechasers are thus saved unnecessary trips.

Excellent prevention work can be done by use of a plane-to-ground loudspeaker for warning brush and field burners. Doubtful cases are referred by radio to smokechasers for personal warning or assistance. As in smokechasing, the plane takes station in a "hot" area and utilizes the tower radio traffic. The planes are well marked and easily identified from the ground.

Chronic prevention problems require more vigorous measures. Handbills, copies of the fire law, and other prevention messages have been dropped to people in the woods in special prevention campaigns. A very serious deer hunter problem has been eliminated by repeated annual projects of this nature.

The possibilities of radio coordinated air-to-ground law enforcement have not been fully explored. The value of the aircraft as a deterrent to incendiaryists is quickly apparent, and results in several areas can be amply verified. North Carolina has not actually sent an incendiaryist to court as a direct result of aerial observation but sufficient observations of fires of a questionable origin have been made to develop field procedures which are accepted with confidence. Cameras are carried on all flights and photographic evidence has been used successfully in one critical felony case.

Brush burner law enforcement offers an easier field. Patroling aircraft happen upon a considerable number of farm fires at the instant of origin, and coordination with the ground smoke-chaser offers no problem to a well-trained pilot. A polaroid camera has been used successfully to photograph escaping fires as they enter the woods. This type of evidence has been unquestioned in court cases to date.

The key to effective use of aircraft in prevention and suppression seems to be in restricting the area covered. This concentration must be to such a degree that the local people recognize the aircraft. The Division of Forestry has now adopted a distinctive color scheme for its aircraft with this purpose in mind.

SUPPRESSION

Scouting of large fires and fires in large inaccessible areas has been the primary aircraft mission since the beginning. Dispatch of a plane to such fires is now automatic. All tractors in the big woods areas are radio equipped and marked for easy identification from the air. They are kept in sight and in communication practically throughout the daylight hours.

At times the fire boss actually directs critical operations from the air. This practice can be overworked, however, and could result in neglect of other important duties. This emphasizes the need for trained pilots and, equally important, trained observers. It also calls for the delegation of responsibility by the fire boss to these key men.

All of the normal scouting functions can be accomplished from the air. In the rough inaccessible swamps of eastern North Carolina the plane is actually the only efficient means of scouting. The time saved is too great to attempt to measure and supplementary ground scouting is seldom needed. By use of two-way radio, amplifier, message drop, polaroid camera, and visual signals, com-

munications are very satisfactory. The success of aerial scouting depends entirely upon the use of the right aircraft and intensive training for pilots, observers, and ground crews.

One of the most vital services performed in scouting work is guiding tractor crews in areas of soft ground and heavy underbrush. In addition to keeping the tractor "afloat," this service makes tractor operation safer by insuring escape routes. Crew morale shows a marked improvement when fire fighters know that the plane will get them to safety in case of emergency and keep them from getting lost or traveling unnecessary distances. The plane observer is literally the eyes of the fire crew. Painting top surfaces of equipment yellow and painting radio calls on the tops of all tractors and other woods vehicles is a must.

Parachute dropping of equipment and supplies from Cub aircraft had to be developed from study of larger plane techniques and knowledge of local needs. A cheap homemade cotton parachute has been designed in 3 $\frac{3}{4}$ -foot and 7 $\frac{1}{2}$ -foot diameters and has proved highly efficient operationally. Some materials are dropped free fall. Most commonly dropped are hot meals, drinking water, coffee, tools, and spare parts. Practically everything from aspirin tablets to items of clothing have been dropped and a fleet of four tractors was supplied with fuel for several hours on one occasion.

Air transportation has been limited by the normal use of two-place scouting planes, but enough has been accomplished, with help from contract planes, to clearly demonstrate the need for a fast four-place plane. In addition to transportation of key personnel such as project fire overhead and tractor drivers, freight transportation could be expanded to include machinery parts and other heavy or bulky items. The type of plane to be selected would have enough reserve power, weight, and stability to operate from roads and restricted strips in weather that limits normal operation.

A National Guard C-47 has been used on one project fire for long-range transportation of personnel. Tremendous savings of critical time and personal effort were realized. This item of military cooperation has been included in fire plans as a standard practice.

Progress in direct attack by aerial delivery of water, retardants, and other chemicals is being watched with considerable interest. Some preliminary experimenting has been done with packaged and free fall water. Intensive tests are planned by the Southeastern Forest Experiment Station of the U. S. Forest Service in cooperation with States and other agencies in the immediate future. Use of the PBY tanker, operated from water, looks like the best possibility for eastern North Carolina at this time. Aerial attack in some form could be the answer to many of the serious problems.

TYPE OF EQUIPMENT

The ideal scouting plane should have these characteristics for—

Observation.—High wing, two-place, tandem seats, slow speed operation (flaps), fast rate of climb, and good cockpit windows.

Safe operation.—Plenty of reserve power, inherent stability, low stalling speed, rugged landing gear, safe cockpit design, and short field takeoff specifications; auxiliary equipment including crash helmets and shoulder straps for the front seat; a bright color scheme on top surfaces for rescue purposes.

Cross-country flying and sustained operation.—Adequate speed, good fuel supply, primary instrument panel, landing lights, CAA (preferably omninavigational type) and forest service radio, comfortable and quiet cabin (to lessen fatigue and help communications), and low operating cost.

While no single aircraft will possess all of these features, the Super Cub type has many. Surplus military artillery spotting aircraft would be excellent.

The four-place plane should have as many of these features as possible with emphasis on the safe operating and cross-country ones. Reserve power is a must in fire work and justifies much higher costs in choice of makes and models. Good built-in radio equipment is also a necessity. All planes of the fleet should meet all critical standards, regardless of variations in local needs, so that all equipment can be used without restriction in an emergency.

TRAINING

Training of pilots, observers, and ground personnel is a never-ending job. Pilots must become rangers to the extent of being able to anticipate and understand what the observer wants to see and the fire boss wants to know. They must understand the fire control organization thoroughly. Low flying in the immediate vicinity of smoke, convection columns, and artificial drafts, and road and strip landing are routine. Even competent crop dusters have much to learn.

The observer is the key man in critical situations and he requires more training than any other man in the entire fire control organization. North Carolina gives formal training to beginners to assist them in mapping, recognizing fuel types, handling communications and drops, and becoming familiar with the aircraft. Only by trial and error over a long period of time can he develop ability to judge rate of spread, flotation of heavy equipment, degree of underground burning in peat bogs, and fire behavior. Personnel must be experienced as fire control overhead and have a love for flying to become qualified.

All regular observers in the North Carolina Division of Forestry are being given pilot training. In addition to the obvious advantages of safety and aircraft familiarization, this program is aimed at alleviating the serious problem of pilot fatigue on project fires. Routine flights, such as trips for fuel and supplies, will be flown by substitute pilots.

Ground crews must be trained to understand the limitations of the aircraft, to handle communications, including emergency signals in case of radio failure, to receive drops safely, and to make full use of the plane and observer. This is accomplished as part of the curriculum at regular annual ranger training schools.

HELICOPTERS

The practical use of the helicopter as an operating aircraft in North Carolina is still in question because of the tremendous cost difference and pilot skill required. A highly trained and experienced crew in a Super Cub can accomplish almost as much in aerial scouting as can a helicopter and with several advantages, including an operating cost about 5 percent of that of the helicopter.

Military helicopters have been used on fire work in the State for about 7 years. Such services as crew delivery and relief in inaccessible areas, rescue operations, hose laying, and direct pumping cannot be approached by fixed wing aircraft. But purchase of a conventional helicopter by the State is not anticipated in the near future.

A new design one-man rotor type aircraft that works on the old autogyro principle (no power to the rotor) is now available at a low cost. Very little is known about its performance as it is still in the developmental stages. But it is a fact that it can be transported in a station wagon, flown safely by any pilot after a brief checkout, and operated at the cost of a Cub. It is designed for tree-top use and can be slowed to about 15 miles per hour (cannot hover). Present flight range is about 2½ hours. Development of this craft is being watched closely.

ADMINISTRATION

Past experience and lessons learned from others have established a few principles of aviation administration that North Carolina personnel have accepted:

1. State-owned aircraft and regularly employed pilots allow a standard of quality and safety unobtainable from contract flying. When justified, maintenance men should also be employed.

2. Because the plane is a fire control tool, all flying operations should be supervised by fire control officers, not set apart in a separate branch of the organization. Operational supervision should be under appropriate field overhead. Maintenance, CAA regulation, certain aspects of training, and other administrative procedures and policies should be delegated by the fire chief to one central office administrator.

3. The central office administrator should be responsible for keeping written policy current and for future planning. All policy must recognize that the pilot is captain of his ship.

4. As a matter of good practice, all administrative personnel dealing with aviation should become pilots.

SUMMARY

An effective program of aircraft support for fire control operations has been developed in North Carolina. Its success has been due to good equipment, highly trained personnel, careful operational use, and written policy. The morale factor which results from a flow of information from the air to fire fighting crews is in itself an important development. With keen administration, careful research, and vision, the probable future growth of aviation as a fire control tool in the Southeast is almost unlimited.

AIRPLANES FOR DIRECT ATTACK ON FOREST FIRES IN THE NORTHEAST

WAYNE G. BANKS

Forester, Northeastern Forest Experiment Station

Airplanes have been used in forest fire control activities in the Northeastern States for many years. In Maine, for example, a hired plane was used as early as 1927 for detection and observation. Since 1933, State-owned and rented planes have been extremely useful in detection work, in scouting going fires, and in transporting men and equipment to fires in areas not easily accessible by road or trail. However, so far as I have been able to learn, airplanes have not been used in direct attack on forest fires in any of the Northeastern States.

A lively interest in the use of planes for dropping water and chemical retardants is being shown by several State forestry departments and fire control personnel in Region 7 of the U. S. Forest Service. There is also interest in helicopters for specialized use. New York State has tentative plans to acquire a plane for use in dropping water or chemical retardant on fires. Maine is reportedly considering the purchase of a helicopter. Forest Service officials in Region 7 are making preliminary plans with the States to obtain equipment and stage demonstrations of direct air attack.

Devastating forest fires will occur in the Northeast when conditions are right for such fires. One area in particular has a history of fires that have crowned and spread rapidly over large acreages. This area embraces about 4 million acres of rather flat land along the Atlantic coast, extending from the vicinity of Machias, Maine, through southern New Hampshire, eastern Massachusetts, Rhode Island, Long Island, and the pine region of New Jersey, to the Eastern Shore of Maryland. The soils in this area are mostly sandy and droughty. Humus types are mostly mors, which means the forest litter accumulates on the soil surface rather than being incorporated as humus. Hard pines, white pines, and various oaks, mostly of scrubby form, make up the bulk of the stands.

Over considerable portions of the coastal area mentioned above, real-estate development in rural wooded sections is advanced. This development consists of yearlong residences, summer homes, and an increasing amount of industry, which in recent years has tended to locate away from urban centers. Much of this real estate is subject to destruction by fast-moving crown fires, and human casualties are a definite possibility.

In view of the relatively level terrain and the generally low tree heights, airplanes could operate very effectively in the coastal areas. Recent reports indicate that under certain conditions,

chemical fire retardants dropped in advance of a crown fire in second growth have succeeded in bringing the fire down out of the crowns so that ground crews could attack directly. In the Northeast it may be possible to knock down some fires in this manner. If prompt air attack were made on incipient fires in hazardous areas, when warranted by burning conditions, many of these fires which might otherwise escape from initial attack should be controlled without difficulty. In dealing with surface fires the plane would drop water or chemical retardant directly on the advancing edges of the fire. Ground crews would of course complete control and mop-up.

Airplanes for direct attack should be tried in this Coastal Plain area. Tests should include drops of both plain water and chemical fire retardants; and insofar as possible they should cover the major fuel types under a variety of weather or burning conditions.

Due to similarity of terrain and cover, a test in any one locality should be fairly indicative of what can be accomplished throughout the northeastern Coastal Plain. McGuire Air Force Base and Lakehurst Naval Air Station are both located within the high-hazard pine region of New Jersey. It seems quite probable that arrangements could be worked out to use their facilities in conducting tests in this area.



Airplane Helps Catch Incendiarist

March 5, 1956, on the Poplar Bluff Ranger District in Missouri started as an uneventful day of an average fire season. No fires had occurred in the morning and none of any consequence were expected.

At noon that day two 22-year-old country boys, with criminal records, were eating lunch at a highway cafe and planning their afternoon activities. And Missouri Conservation Commission Pilot Bob Larkins was in the air patrolling the State-protected land west of the Shawnee National Forest.

An hour later the 2 boys parked their car, went north of the main highway, and set 2 fires. They crossed the highway and walked about a mile east through the woods where they made the third set. Then for approximately 2 miles in a southeasterly direction they set fires every 25 to 50 yards.

Within minutes after the first set, which was discovered by a Forest Service lookout, crews were dispatched to the fire and others were being organized. As Ranger Paul R. Larsson and the headquarters fire crew reached the fire, they received word by radio that Pilot Larkins was scouting the fire and had seen the two men making a set. The pilot added that he believed he could keep one of the fire setters in sight and that if someone would come to the vicinity he was circling there would be a good chance of catching him.

By a circuitous route of about 7 miles by car and then on foot, Ranger Larsson arrived below the plane which was circling just above the tree tops. On the ground, with his shirt off and his face buried in the leaves and needles, lay the fire setter. Pilot Larkins shouted down to the ranger, "That's him!"

The fire setter was taken to the ranger station and turned over to the FBI. His trial will be held in Federal court after he has been released from the State penitentiary where he is serving a 2-year sentence for a crime committed before his fire-setting spree.

This is an excellent example of airplane and ground coordination as well as cooperation between the State and Federal organizations.—*Shawnee National Forest.*

WATER DROPPING FROM FLOAT-EQUIPPED PLANES

Ontario Department of Lands and Forests

Development of equipment for dropping water from float-equipped aircraft in Ontario dates back to 1944-45. At that time a system of valves was built into the floats of a Norseman aircraft to enable the pilot to take water into the floats while on a lake and release it as required while in flight. This system was abandoned for several reasons, the main one being the inability to make a drop in sufficient bulk.

By 1950 we had developed a water bombing technique. This involved the use of latex-lined paper bags each filled with 3 imperial gallons of water, dropped in salvos of up to eight bombs from a roller conveyor mounted in the floor of the Beaver aircraft fuselage, the drop being made through the camera hatch.

Our most recent development, the installation of a 90-gallon rotating tank on each float of the DeHavilland Otter, is briefly summarized in this article. The tanks and control system were developed by the Air Service Division of the Ontario Department of Lands and Forests at Sault Ste. Marie, Ontario. The primary aim was "To drop the greatest possible amount of water in the shortest possible time with a minimum delay in pickup and assembly, the whole operation to be handled by one man—the pilot."

The "greatest amount of water" was governed by the weight load capacity of the aircraft. The time it took to release the water depended on the size of the discharge opening which, since the aircraft would be moving at approximately 120 feet per second, would have to be quite large if the water was to be concentrated at the target.

Investigations proved that the maximum discharge area allowable with an internal tank emptying through the camera hatch in the rear of the fuselage was 150 square inches. This was obviously insufficient. The port cargo door was then considered as an alternative and we built an internal mockup tank which allowed an opening of 400 square inches. This was still not considered satisfactory. We also had the problems of release mechanism and floor anchorage.

Because of these problems and limitations, the internal tank was abandoned in favor of two rotating tanks carried externally. This system offered the following advantages: (1) Total discharge area of 1,400 square inches; (2) carrying the tanks would not interfere with normal operation and load capacity of the aircraft; (3) no appreciable change in the center of gravity of the aircraft; (4) it could be applied to both Beaver and Otter aircraft which make up our air fleet.

Each tank, made of 0.081 half hard aluminum, is 6 feet long and 22 inches in diameter. The opening is 10 inches wide and runs the entire length of the tank (fig. 1). Total capacity of each



FIGURE 1.—Front view of starboard tank.

tank is 97.5 imperial gallons, operational load is 80 imperial gallons. Tubular frames support the bearings and provide attachment points to eye bolts mounted permanently on the floats.

The two filling scoops are made of $2\frac{1}{2}$ -inch-diameter steel tubing welded to a tubular frame attached to the float at the

beaching gear lug and supported by two additional eye bolts at the top of the float. Each scoop is removed by the withdrawal of the clevis pins from the eye bolts.

The tanks are filled in 10 seconds at an airspeed of 40 m. p. h. under calm conditions. Total time from "touch-down" empty to "take-off" full (wind 5 m. p. h.) is 18 seconds.

The tanks are rotated by means of a lever on the floor of the cockpit at the pilot's right hand. This lever actuates control cables connected to 5½-inch aluminum pulleys fixed to the front end of each tank axle. The tanks return to the upright position when the control lever is released.

Although the tanks do not interfere greatly with the normal operation and load carrying capacity of the aircraft, they can easily be removed. Two men can install the tanks in 10 minutes. Total weight of tanks and scoops is 175 pounds. The tanks can easily be carried inside the aircraft.

FIELD TESTS

Field tests were needed to determine pattern and density of water distribution. Several 160-gallon drops were made from an estimated height of 100 feet to a dry concrete surface (fig. 2). In addition, two drops were made with part loads equal to the carrying capacity of the Beaver aircraft (50 gallons per tank). For various flight directions in relation to wind, the water pattern had the following dimensions, with the longer along the flight line:

	Wind velocity (m. p. h.)	Pattern	
		Length (feet)	Width (feet)
160-gallon drop:			
Into wind.....	10	285	85
Down wind.....	10	315	85
Cross wind.....	2	375	75
Cross wind.....	8	260	100
Cross wind.....	16	285	135
100-gallon drop:			
Into wind.....	10	320	90
Cross wind.....	8	260	100

Observations indicate that although the area of greatest saturation for a given height varies little under the above wind speed range, the wind does blow the lighter spray a considerable distance when no trees are present to intercept it.

An arrangement of rain gages set out in an open field, under a coniferous cover, and in a hardwood stand provided specific measurements of water density. Each area was subjected to ten drops into the wind aimed at a target in its center. The 25 rain gages in the open field, where wind velocity was 5-7 m. p. h., showed traces of water as far as 75 feet out on both sides and almost 300 feet along the line of flight.

The coniferous stand, typical black spruce-balsam fir, had 460 trees per acre with an average diameter breast high of 7.6 inches and an average height of 78 feet. The 24 rain gages were placed at 10-foot intervals in four rows 10 feet apart. Ten drops were made at 3-minute intervals from an estimated height of 100 feet.



FIGURE 2.—Water drop from tanks on the floats of an Otter aircraft.

Relative humidity, taken at intervals in the center of the target area beneath a large tree, rose from 65 to a maximum of 87 percent. After the fourth drop, a steady dripping of water from the trees similar to that experienced during a brisk rain shower continued throughout the test period and for 30 minutes after the last drop, at which time the relative humidity had decreased to 69 percent. Water density varied from 0.025 in some gages at the outer edge of the 30-by-50-foot target area to 0.25 toward the center. Distribution in general was fairly uniform, with an average density of 0.085.

The hardwood stand had 1,980 trees per acre with an average diameter breast high of 2.9 inches and an average height of 27 feet. This was an immature stand of aspen with scattered white spruce and birch having an understory of balsam fir and scattered willow, alder, and mountain maple. Here also the 24 rain gages were set out at 10-foot intervals in four rows 10 feet apart.

Ten drops were made at approximately 3-minute intervals from an estimated height of 75 feet. Trees in the center of the target were swayed violently by the impact of the water. After

the tenth drop, the target area was completely saturated. Relative humidity in the target area rose from 73 to 93 percent after the third drop. Water density recorded by the gages ranged from 0.03 to 0.40 and averaged 0.225, about $2\frac{1}{2}$ times that for the coniferous stand. Except for a few gages, water was very well distributed.

CONCLUSIONS

The factor that most influences water pattern and density is altitude. The lower the aircraft is flying at the point of release, the greater the knockdown effect of the water, the greater the density, and the smaller the area covered.

The trajectory of the water mass changes progressively as the water meets the resistance of the air, breaking up into smaller and smaller particles which do not maintain the initial forward speed but are increasingly affected by wind and gravity.

In practice, the direction of the dropping run will depend on topography, forest type, and smoke conditions. A rough formula for drift when dropping from a height of 100 feet above the ground is 8 feet of drift per mile per hour of wind regardless of the direction of flight, for example, when dropping from 100 feet in a 10-m. p. h. wind, the pattern will be offset 80 feet in a downwind direction.

The immediate tendency is to judge the potential of this equipment on the effect of a single drop. This, is like assessing a machine gun on the effect of a single round fired from it or judging the potential of a backpack pump on a single filling.

The total effect of the equipment must be measured by the number of gallons of water delivered to the fire in reasonable operating time. This obviously varies with the distance the aircraft must fly to the water source. The accompanying tabulation shows the number of loads per hour and the total gallons per hour that may be delivered under average conditions. Under adverse conditions or hilly terrain the delivery rate will vary slightly.

Distance of fire from nearest landable lake
(miles):

1	.....
2	.....
3	.....
4	.....
5	.....
6	.....
7	.....
8	.....
9	.....
10	.....

Water delivery per hour

<i>Imperial gallons</i>	<i>Loads</i>
2,900	18.1
2,100	13.1
1,640	10.2
1,325	8.2
1,125	7.0
975	6.0
850	5.3
775	4.8
690	4.3
625	3.9

The tabulation may also be used to determine the number of aircraft that should be engaged on a fire or sector of a fire. For example, if the nearest water source is 2 miles away, one aircraft can drop 2,100 imperial gallons per hour, whereas it would take two aircraft to deliver at approximately this rate if the water supply were 6 miles away.

The most valuable features of this equipment are—

1. The speed at which the tanks can be refilled.
2. The whole operation is conducted by the pilot alone.
3. The equipment can be used simultaneously and in conjunction with other control measures without danger to the fire fighters.
4. The equipment may be carried at all times either in the operating position or within the fuselage of the aircraft (two men can complete the assembly in 10 minutes) without undue interference with the ability of the aircraft to perform other work.

A blender unit is presently being considered to introduce a wetting agent into the water as it passes through the intake pipe. Due to the abundance and convenient location of water, the addition of chemical fire retardants is not being considered for the present at least.

Construction of water dropping tanks and fittings for all six Otter aircraft has now been completed. Experimental work on Beaver adaptation has also been completed and plans are now under way for manufacture of the units.

Although it is realized that this may be only another step forward toward a better means of aerial fire attack, the future for this new development is extremely bright. Inquiries regarding further detail are welcome and should be addressed to the Division of Forest Protection, Department of Lands and Forests, Parliament Buildings, Toronto 5, Ontario, Canada.

AIR TANKER REPORT—CALIFORNIA, 1957

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In 1956 air tankers became a reality as tactical support for ground fire fighters in California.² They demonstrated their value as a new fire tool with great success. They also showed they had many limitations.

In 1957 the number of fires on which air tankers were used quadrupled, as did the number of air tankers available for use:

Plane type (capacity):	1956	1957
Stearman and N3N (100-180 gallons) number.....	7	20
TBM (400-600 gallons).....do.....	1	4
PBY (1,500 gallons).....do.....	0	1
C-82 (2,000 gallons).....do.....	0	1
Fires attacked.....do.....	25	101
Water dropped.....gallons.....	83,000	125,000
Retardant dropped.....do.....	66,000	500,000

This expanded use provided an opportunity to study the limitations of air tankers and to determine what must be done to make the most effective use of this new tool. Since the aircraft were used on fires throughout the State, a large variety in fuels, topography, and burning conditions was encountered.

AIR TANKER EFFECTIVENESS

Analysis of reports indicated that air tankers were completely effective on about 25 percent of the fires; that is, all drops either extinguished the fire or retarded it so that ground forces were able to complete control. On 65 percent of the fires effectiveness varied widely. On the remaining 10 percent all drops were termed non-effective.

Fire bosses said that the air tankers were generally most effective on initial attack. The small fire offered less opportunity for misplacement of drops. If the fire was not extinguished, the air drops held the fire down until ground crews arrived.

¹Maintained at Berkeley, Calif., by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of California. This report was prepared in collaboration with the California Air Attack Executive Committee, which coordinates air attack research and development in California. Representatives are selected from the California Division of Forestry and from Region 5, Arcadia Equipment Development Center, and California Forest and Range Experiment Station of the U. S. Forest Service.

²Ely, Joseph B., Jensen, Arthur W., Chatten, Leonard R., and Jori, Henry W. *Air Tankers—A New Tool for Forest Fire Fighting*. Fire Control Notes 18 (3): 103-109, illus. 1957.

On larger fires the air tankers helped secure control and held burned acreage to a minimum by dropping on key points such as running fingers, spot fires, and slopovers. In some places, where inaccessibility or lack of time had prevented mechanical construction of firebreaks, borate lines were laid down by the air tankers ahead of the fire and successfully retarded the spread of the fire. These lines were generally most successful in the lighter fuels.

AIR TANKER LIMITATIONS

Ground action.—Practically all air drops had to be backed up by ground action. Delays in ground action frequently resulted in loss of temporary control gained by the air tankers.

Interception by fuel canopies.—Interception by dense brush or timber canopies reduced the effectiveness of air drops on ground fires. Two or more drops on the same spot were often necessary to penetrate the crowns and hold the fire. Crown fires in these canopies, however, were often knocked down by accurate drops, thus permitting ground forces to move in.

Topography.—Rugged topography adversely affected the height and direction of flight, airspeed, and accuracy of drop placement.

Winds.—Strong or gusty winds prevented low approaches at minimum speeds and caused drift or complete dispersal of the dropped material.

Radio communication.—Many field reports stated that the air tankers would have been more successful if radio communications had been available. "Bird-dog" planes flying experienced fire personnel were of great help in visually directing the placement of air tanker drops but did not completely fill the need for direct air-to-ground and air-to-air contact with each pilot. The need for direct communication to each air tanker pilot was especially noticeable on larger fires where close support of ground action was required. Uninstructed pilots often made their drops on the hottest burning spots. These spots were frequently inside the fire front and presented no real threat. Lack of communication also affected air safety, which was of critical importance on large fires where close control of the various types of air activity was necessary.

Pilots.—Many reports again emphasized that all air tanker pilots should receive basic instruction in fire control strategy and tactics and fire behavior.

Air tanker facilities.—The round-trip time for the air tankers also affected their efficiency. Distance of refill ports from the fire-line and limited facilities at these refill ports added to round-trip costs. Planning of such facilities is urgently needed to eliminate confusion and loss of time when staging a large air attack operation (fig. 1).

Air tanker design and mechanisms.—Continuing investigation and improvement in air tanker design is another need. Some of the existing gate sizes and opening mechanisms proved to be inadequate. The ability of tankers to make multiple drops was found to be desirable at times (figs. 2 and 3). Pilots with such



FIGURE 1.—N3N taking on load of borate from a portable refilling station.



FIGURE 2.—TBM tank designed and built by the California Division of Forestry.



FIGURE 3.—TBM with California Division of Forestry tank making drop.

planes were able to release the amount of material needed for a given situation, either to test wind effect or to drop on a fire of certain size and heat volume. To be effective, however, it was necessary that the amount of material released in each drop be matched with the airspeed so that the material reached the ground in sufficient quantity.

Dispatching.—Air tankers often were dispatched to fires after control had been achieved by ground action. In many situations fire bosses believed that if the air tankers had been dispatched earlier, the fire could have been controlled at much less cost in suppression effort and values destroyed.

AIR TANKER COSTS

Rental for air tankers is not low. Considering the additional costs of fire retardants and of personnel necessary to handle ground and air operations, tankers can be an expensive tool. The decision to use them must be made with great caution by budget-minded administrators. This decision is of utmost importance when we stop to consider that in California approximately 95 percent of all fires are controlled in the "A" and "B" size classes with current equipment and methods of operation. Reviewing the past two seasons of air tanker use, it is apparent that much more study will have to be made of costs and returns before we can specify the proper time and place for their use.

1957 AERIAL-TANKER PROJECT FOR REGION 6

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The Wenatchee has 2 million acres lying east of the summit of the Cascade Mountains to protect from fire. From east to west, fuel conditions change from steep cheatgrass slopes along the Columbia River to typical open ponderosa pine forest, through dense lodgepole pine stands, and into the typical heavy fuels of the Douglas-fir-hemlock type. Three hundred thousand acres at higher elevations have no fixed detection. Fuel types there vary from dense fir timber in the valley bottoms to scattered subalpine clumps at higher elevations, and the terrain is often rugged and precipitous.

Lightning and man-caused fires are generally evenly divided in number. In 1956, however, we had 200 fires of which 160 lightning fires occurred within a 10-day period. Forty of these were handled by smokejumpers. The man-caused fire season lasts from early April into November, with debris-burning fires the early problem and hunter fires the late problem.

In 1957 the Wenatchee conducted a pilot aerial-tanker project financed by Region 6. The operator of a local agricultural aerial spraying service gave us space for installation of borate mixing apparatus (fig. 1), and devised and installed a gate release valve on two of his planes at his own expense (fig. 2). The



FIGURE 1.—Slurry mixing setup. Borate storage on left. Water storage in large bottom tank. Slurry storage in 1,200-gallon tank on top.



FIGURE 2.—Gate release valves. Pilot can use any of three opening sizes. When the large-sized opening is opened and closed quickly, 2-second dumps of 30 gallons can be made. This is advantageous on small fires.

Piper Super Cub could operate safely with only 60 gallons of borate slurry, but it carried enough fuel for a $4\frac{1}{2}$ -hour flight; this permitted rapid dispatching to distant back-country smokes. The Stearman could operate safely with 100 gallons of slurry, but carried enough fuel for only a $1\frac{1}{4}$ -hour flight. We made no commitment on minimum hours of use for the planes, and no standby time was paid. Actual flying time cost \$120 an hour for the Stearman tanker, \$90 for the Super Cub tanker, and \$21 for the Super Cub reconnaissance plane.

Our instructions were to use the tankers on a variety of fires over the full spread of our fuel types and terrain conditions. A light fire season resulted in tanker attack on only seven fires. However, these seven gave a good spread. Two were fast-moving cheatgrass fires on steep slopes. One was an operator fire in selective logging slash. One was a fast-moving dry lightning fire, another a high-country hunter fire in the subalpine type.

The largest of the 7 fires was a 60-acre railroad fire burning on a steep slope in dense second-growth Douglas-fir. Aerial attack by the 2 tanker planes, dumping 400 gallons of borate slurry and 520 gallons of wet water on this hot crown fire, did not knock it out of the crown completely. Fire overhead generally agreed, however, that the aerial tankers were the decisive element of the attack in that they prevented the fire from blowing up and spreading over 2 to 10 times the 60 acres. The dumps were made first across the top of the fire about 50 yards ahead of the flames, and then down the hottest flank. Consistently, as the moving crown fire hit the treated strip, it slowed down for a few minutes. This

checking of the rate of spread was just enough to permit the 75-man control crew to complete their lines and burn out, with control accomplished at 11:45 p. m. of the day the fire started.

The 2-acre dry lightning fire occurred in ponderosa pine second growth on a moderate slope and with a 20 m. p. h. wind. One Super Cub tanker plane, 4 smokejumpers, and an 8-man ground crew all arrived on the fire at about the same time. The first dump of 70 gallons 30 to 50 feet ahead of the fire, applied in 2 passes, prevented further crowning.

The 6-acre grass fire occurred on a 60-percent southeast slope with a 12-mile west wind. The Super Cub dumped two 90-gallon loads of wet water, the first load across the top and the second down the hottest flank. The dump was made directly on the fire edge and dampened it down quite thoroughly. There is no question that aerial-tanker attack on a fast-moving grass fire is highly effective.

The 2-acre, high-country hunter fire picked up by aerial patrol was just starting to crown in subalpine timber on a 40-percent slope. One dump of 100 gallons of borate slurry by the Stearman knocked the fire down so that it had not spread farther when the smokejumpers arrived 30 minutes later.

A unique use of the aerial tankers was made on an October cheatgrass and sagebrush fire of 50 acres. The fire moved rapidly up a steep slope and threatened the hangars of the Wenatchee Air Service at which our tanker project is based. The Air Service manager promptly loaded up the Super Cub with wet water and the Stearman with borate and dumped five loads of each on the approaching fire. By the time the rural fire department arrived, the fire had been completely stopped with no property damage done.

Our borate slurry mixing technique is the same as that developed in California (fig. 1). By placing the slurry storage tank about 12 feet above the ground, we have enabled the pilot to pull in his plane alongside and load by gravity (fig. 3). The gate release mechanism gave us flexibility in application, permitting more effective use of the borate or wet water on light fuel grass fires and also on small lightning smokes. Despite the high cost of plane rental and of the mixed borate slurry, the use of aerial tankers on fires of this type is economical. Although our experience with aerial tankers is limited, we have listed tactics to be employed and key points to be considered in meeting our conditions.

TACTICS

Lightning smokes and other small fires.—Either wet water or borate is effective. Use the large gate opening and make several passes, with the pilot opening and closing the gate at the minimum 2-second interval. This permits several 30-gallon drops directly on the smoke. If the fire is in a snag or green timber, change direction on each pass (providing topography permits more than one safe approach and getaway).



FIGURE 3.—Pilot loading Stearman by gravity.

Running fire in light fuels.—Wet water is just as effective as borate, and it is cheaper and requires no mixing apparatus. One pint of the liquid wetting agent (Solvold Fire Wet or equal) poured into the 100-gallon load of water just before the plane takes off will mix itself in flight. Tanker should attack hot spots directly, working independently of ground crews. A cheatgrass fire on a steep slope should be hit with the first plane load at the uphill point; this involves several passes across the face of the slope, on the flames or immediately ahead. Use small or medium gate opening and short interval passes. Following planes should then make a run down the hottest flank directly over the fire edge, using the small opening. A downhill run with a loaded plane is much safer than an uphill run. If the fire edge is fairly straight, the tank can be emptied with one long pass. If not, 2 or 3 shorter passes will utilize the load more effectively.

A running fire in medium to heavy fuels.—Use borate only, unless the fire can be hit directly. Hot spot the fire, working independently of ground crews. This gives the ground crew time to build lines and burn out. Use same plane tactics as with light fuels, except use large gate opening. Ground-air coordination is required on one point; aerial tankers should not dump on a back fire unless requested to do so to reduce heat and spotting.

Fire too hot to check by direct tanker attack.—Use borate only. Use the middle opening of the gate valve for light fuels, the large opening for heavy fuels. Stay away from the main fire; strengthen the lines being prepared by the ground crew. Dump slurry along the outer edge of lines on ridgetops, roads, and other firebreaks;

also over the entire area of a saddle. Attack spot fires across the line directly, using the 2-second, open-and-close technique and the large opening.

Project fire or lightning bust.—During night move mixing setup to the nearest airstrip. Mobilize all available tanker planes. Attack at daylight (winds normally light, smoke normally drifted down-slope, humidity normally up). Dump wet water on fire edge where the main ground crew is using a direct method of attack. Then dump borate slurry to supplement the fire boss' plan of indirect attack. Hit it hard while wind and smoke are down.

KEY POINTS

1. An aerial-tanker project requires an aerial-tanker boss. He must be an experienced fire man. He must be physically capable of riding a small plane in turbulent air and during steep dives and abrupt pull-outs. He must be capable of making independent fire decisions. His job involves not only riding the "bird dog" plane and keeping in touch with the fire boss by radio, but also setting up the slurry mixing apparatus, planning mobilization of plane and overnight moves to a new airstrip, and developing new techniques to fit this new method of fire control.

2. The pilot of the "bird dog" plane should be a man with much experience in mountain flying and in agricultural spraying or other flying that requires close-to-the-ground maneuvering. He should develop wing signals so that he can convey to the incoming tanker-plane pilot how and where the tanker boss wishes the load deposited. Plane to plane radio would perhaps be more effective than wing signals; in our limited operations, we found that the latter were adequate.

3. The pilot of a tanker plane must be fully capable of handling the plane in fire conditions and over rough terrain. Except when safety factors do not permit, he must be willing to accept the plan of attack established by the tanker boss.

4. Initial attack with the aerial tankers is highly important on a fire that starts during severe burning conditions. The monitor of our forest radio net (a centrally located district headquarters assistant) is authorized to dispatch the unit immediately to any fire when available information indicates it would be useful. This insures that the effectiveness of aerial-tanker attack is taken advantage of during the crucial first few minutes. The district ranger can decide later whether to continue the tanker attack or terminate it. If several fires develop, the forest dispatcher must determine priorities.

5. Good visibility is essential to safe and effective operation of the aerial tanker. Obviously, a pilot must have daylight and a cloud ceiling high enough to permit approach and attack. Nor can we expect a pilot to operate close to rugged terrain when his visibility is obscured by smoke. The smoke limitation is a very real one and sharply limits the use of aerial tankers once a fire has become large.

6. Air turbulence during lightning storms limits use. It is not safe to bring a loaded plane within 50 feet of rugged terrain if the air is turbulent. Moreover, the material dumped will be blown away from the target. If a lightning storm is wet, effective use can still be made of the tanker after the air has quieted down. In the event of a dry lightning storm, however, fires often spread rapidly and we should not expect too much help from small aerial tankers.

7. Strong prevailing winds also limit the effectiveness of this technique, particularly if topography is rugged and the fire has begun to crown. Both safety of the pilot and dispersion of the dropped material are affected. Our 60-acre, second-growth fire brought out an interesting sidelight on this point. The fire started on a day of light wind. If the aerial tankers had not assisted in controlling at a modest 60 acres and a much larger fire had resulted, we would have been in serious trouble the next day when the prevailing wind was quite strong.

8. The fuel type has a direct bearing on aerial-tanker use. Our 60-acre fire in dense second growth on a steep slope demonstrates that the slurry is of some value in this fuel type, and that aerial-tanker attack certainly should be used. However, the wind was very light that day. Also, the second growth was only 30 to 40 feet high. We do not feel that the small aerial tanker would be of much value on a crown fire in old-growth Douglas-fir, particularly with a strong prevailing wind.

9. Distance from the air field to the fire or fires. Stearmans carry only $1\frac{1}{4}$ hours' gasoline supply. Be prepared to move to the nearest airstrip.

10. A forest that depends upon agricultural spray planes should not take availability for granted. One problem is that an agriculture air service is apt to be reluctant to tie up most of their planes on fire suppression during the height of an agricultural season. This problem can be met by signing up one or two planes from each of several companies within an hour's flying time of the forest. Prior arrangements for standby, ferrying, plane service at other airstrips, and mobilization of daylight attack are important.

CONCLUSION

The indications are that aerial-tanker attack can be effective on perhaps half of our fires. The cost-benefit ratio of aerial tankers goes up in proportion to roughness of terrain and to inaccessibility of the fire to ground crews. Even smokejumpers cannot land directly at a fire in cliffy terrain or in a snag patch. Aerial tankers can operate effectively under such conditions, providing the air is reasonably quiet, the terrain permits approach and getaway, and visibility is good. When operating conditions are right, the aerial tanker is a wonderful tool for initial attack.

TESTING THREE NEW AIR TANKERS

Arcadia Equipment Development Center, U. S. Forest Service

In the spring of 1957 three new air tankers of a new class were in the last stages of being fitted with tanks of differing designs and capable of carrying from 400 to 1,500 gallons of water (fig. 1). Since we had no data regarding drops from these aircraft, the Development Center was requested to conduct tests.

Some of the objectives desired were (1) to establish distribution patterns for water drops from these aircraft at different elevations and various gate opening combinations; (2) to evaluate gate release and control mechanisms; and (3) to determine impact forces on the ground from the water drop.

The three air tankers submitted for testing were a PBY-6a owned by a private operator in Long Beach, Calif., a TBM owned by an operator in Santa Ana, and a TBM owned by the Forest Service.

The owner of the PBY utilized the unique feature of his amphibious craft, the watertight hull, to hold fire suppressants. The fore-and-aft compartments on either side of the wheels were equipped with internal tank walls fastened to the hull. A pair of hydraulically operated doors were located on the bottom of each tank, thus providing all, one-half, or train dump combinations. Furthermore, the doors could be quickly closed and sealed by the pilot. Total capacity of both tanks was 1,500 gallons, although

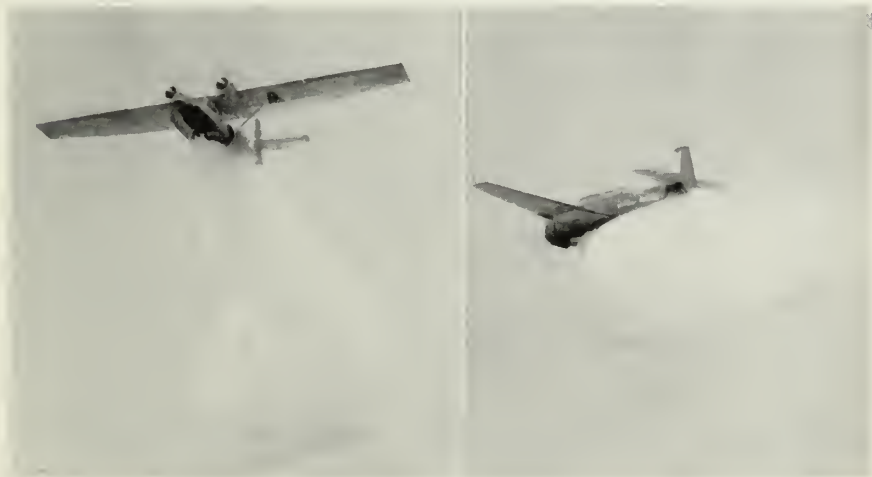


FIGURE 1.—Water drops: *Left*, PBY, 1,500 gallons; *right*, TBM, 400 gallons.

normal fire flying since these tests has been about 1,000 gallons of borate. Each door has approximately 1,000 square inches area.

The privately owned TBM had a 515-gallon tank fitted into the torpedo bomb bay. The tank was divided longitudinally into three compartments, each having a single door with an opening approximately 575 square inches in area. Electric bomb shackles were used for locking and tripping the doors, which necessitated manual closure on the ground. Individual, combination, or sequence drops could be made with this arrangement.

A 400-gallon tank installed in the Forest Service TBM had two doors which completely covered the bottom of the tank. Since the tank was separated longitudinally, each side dumped 200 gallons. These doors also could be operated independently. After the latches were tripped and the doors dropped open, hydraulically operated levers automatically returned the doors to the closed position. By reversing the release levers the pilot could then re-lock them. Each door had approximately 900 square inches of area, and in essence "dropped the bottom" of the tank.

Conducting the tests.—An unpaved area on the airport at Santa Ana, Calif., was obtained for setting up a grid collection system 150 feet wide and 600 feet long. This grid system consisted of 121 specially built steel paper-cup holders for a standard 10-ounce cup. The cups were maintained at a uniform height above the ground, and the cups were completely enclosed except for the open top. Each holder bore a number defining its position in the grid, so that the cups could be numbered and identified after each drop. Each cup and a lid was weighed to the nearest tenth of a gram prior to the drops. After each drop, the cups were covered, numbered, and reweighed. By plotting values of the grid, contour lines of concentrations could be drawn.

To determine the impact force of drops, a box having hinged panels one square foot in area was located in the grid. Two panels, one in the vertical and one in the horizontal plane, were held by force rings employing strain gages. Forces were recorded electrically through cables to a recording oscillograph.

Other instruments were on hand for measuring weather conditions. Height of aircraft above the ground was checked by an abney mounted on a tripod. Ground to air communications were maintained at all times. Forty-four drops were made at heights varying from 15 to 200 feet.

Results of tests.—From the study of all patterns (fig. 2), it appears that gate openings of 1,000 square inches for each 200-250 gallons yield good clean drops. Proper venting of tanks also helps. Optimum altitude for the TBM's appears to be 50-150 feet, and 75-150 feet for the PBY. Small patterns will result from altitudes below 50 feet. A 10-m. p. h. side wind will shift the pattern of a drop made at 100 feet about half its width from the drop line.

The PBY had the highest consistent concentrations in the patterns, with values up to 19 gallons per 100 square feet recorded.

Gates that can be relocked in flight appear to have an added safety advantage in the event they fail to open.

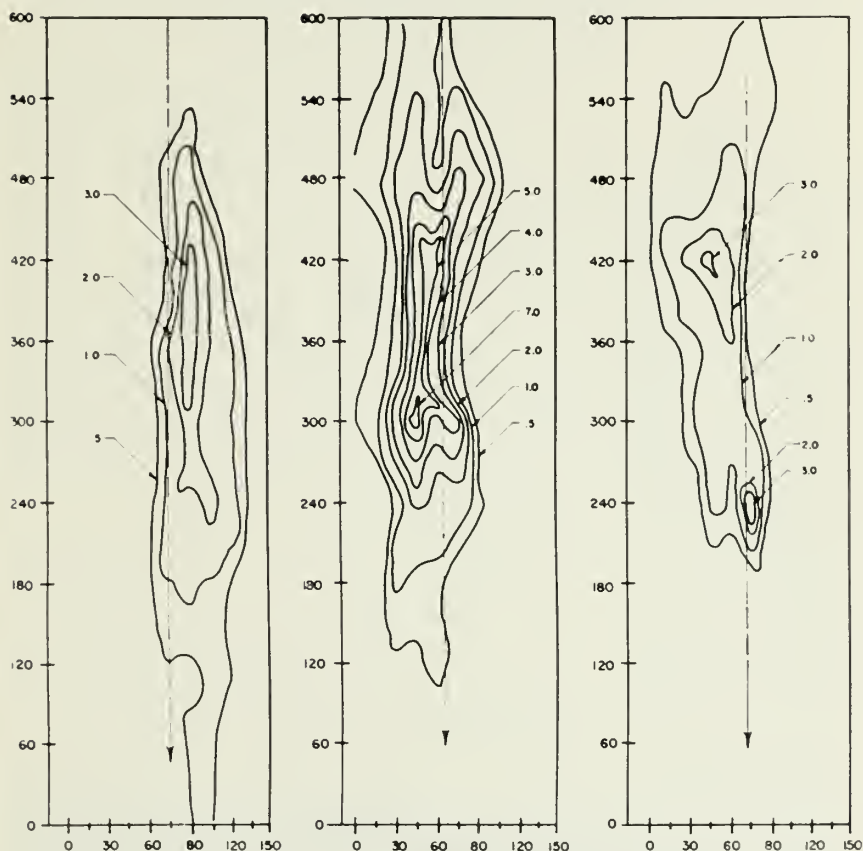


FIGURE 2.—Three typical drop patterns: *Left*, Santa Ana TBM, 515 gallons at 50 feet; *center*, PBX, 1,500 gallons at 70 feet; *right*, F.S. TBM, 400 gallons at 100 feet. Contour lines show concentrations in gallons per 100 square feet. Airspeeds averaged 110 m. p. h.

Impact forces from drops below 25 feet can be very great, particularly in the horizontal direction. An instantaneous acceleration of about 4 G's was recorded. The safest procedure for ground crews who might be subjected to very low drops would be to lie prone with heads, protected by hard hats, toward the oncoming aircraft.

FIGHTING FIRES WITH AIRPLANES AND SODIUM CALCIUM BORATE IN WESTERN MONTANA AND NORTHERN IDAHO—1957

H. K. HARRIS

*Forester in charge, Missoula Equipment Development Center,
U. S. Forest Service*

On August 8, 1957, the Northern Rocky Mountain Region of the U. S. Forest Service initiated experimental operations to determine regional possibilities for retarding the spread of wild-fires by aerial applications of sodium calcium borate and water, based upon earlier developments in California. A local contractor of flight service equipped a Ford Tri-motor with three 100-gallon tanks, each with a separate dump valve and control. The 300 gallons was believed to be the maximum safe load if the borate and water mixtures were to be dropped from low elevations in the excessively rough topography common to the Region's remote areas. Three tanks were selected for control of the loading and to permit adjustment in the event the pilot erred in "spotting" the first tank on the selected area. Three charges or loads are also believed necessary if the pilot needs to place retardant entirely around a small spot-sized fire on a single trip.

On August 9, two loads of water were dropped on the ramp at the Aerial Fire Depot. Spread and concentration of the water were observed and operation of the dump valves was checked. We followed these tests by field application in open grass and timbered areas to observe effects, conduct flammability studies, and check our information on concentration. These preliminary runs were good training for pilots as well as selected smokejumpers who were to report the results on fire application (fig. 1).

Following the training period the Ford tanker was dispatched to 8 selected fires. Smokejumpers were available in most cases for



FIGURE 1.—Ford Tri-motor cascading borate over timber.

fast control action and to observe retarding effects. A spotter accompanied the plane on each load to assist in selecting the dump spot and record the effects as observed from the air. Participating personnel later met to discuss the action and the possibilities. The following details were reported:

<i>Fire number</i>	<i>Loads¹ (number)</i>	<i>Flight time (minutes)</i>	<i>Fire character</i>	<i>Report</i>
1.....	2	75	6 acres. Running.	Fire flanked borate—insufficient number of drops.
2.....	1	120	13 acres. Spreading in scattered timber.	Load ineffective in timber.
	1	120	Smouldering spots in snags, windfall, and brush.	Good coverage; held fire down.
3.....	1	175	Class A. Creeping in scrub timber and duff. Several small fires.	Held some smouldering duff; coverage good on snags and windfalls.
4.....	1	70	Heavy duff with thicket of fir and pine; some open, rocky area.	Ineffective in duff and under trees; some benefit in open.
5.....	1	120	Creeping. Dense brush cover; several snags and a few windfalls; no green timber.	Retarded advance temporarily. Control obtained before plane arrived. Did good job on brush.
6.....	1	85	Spot size. Alpine-type heavy duff; some windfalls.	Drop made in very strong winds. Light application resulted but effective on duff.
7.....	1	30	Alpine fir with several windfalls and considerable heavy duff.	Held fire; simplified control and mopup.
8.....	1	50	1.5 acres mill debris, grass, brush. Spreading.	Hit hot spots—good judgment in dropping—highly effective.

¹300 gallons per load; 4 pounds borate per gallon.

General results were definitely encouraging. The fire observers brought out that effectiveness was greatly reduced by a heavy tree canopy. Where such a condition existed, retarding effects were limited, and general opinion held that much heavier concentrations will be required.

Cost of borate, applied on the fireline, averaged \$280 per fire. All the fires were considered to be of smokechaser size and were selected with possible benefits from borate drops in mind.

A single load (300 gallons) averaged 86 minutes flying time, which indicates the considerably restricted area used in the test. Borate is estimated to cost approximately \$1.50 per gallon on the minimum size operating area (average cost per gallon during these operational tests was \$0.747) for application to fires of smokechaser size.

Although our 1957 testing was definitely limited, we believe the possibilities of retarding the spread of small fires by cascading borate, or the use of some other aerial technique, are worthy of further investigation. We are confident that costs will be reduced with greater use, faster flying and larger capacity aircraft, and careful selection of operational bases. The special performance possibilities of the Ford Tri-motor and the helicopter also must not be overlooked in future planning.

PLANNING FOR SMOKEJUMPING

L. M. STEWART

Air Operations Officer, Region 1, U. S. Forest Service

Smokejumping is no longer experimental and is paying fire control dividends in the mountain areas of U. S. Forest Service Regions 1, 3, 4, 5, and 6 (Montana, Idaho, Arizona, New Mexico, California, Oregon and Washington), as well as Yellowstone and Glacier National Parks (fig. 1). In addition, the Province of Saskatchewan operates a 16-man unit and the U. S. Bureau of Land Management plans to activate a small Alaskan unit in 1959.

There is steadily growing recognition of the value of smokejumpers as trained and highly mobile reinforcements for the control of threatening fires in relatively accessible areas. However, it is believed that such use must be considered as incidental from a planning standpoint. Evaluation of proposed jumper units should be limited to probable value in areas otherwise deficient in manpower where, because of poor access by other means, smokejumping promises improvement in first-attack action. Smokejumping is far from a cure-all for all back-country fire suppression problems. Before seriously considering initiation of a unit, land managers should obtain competent advice on the effect of the following factors, singly or in combination, in the specific areas under study:

Elevation.—Ground elevations above 8,000 feet may limit jumping.



F-470029

FIGURE 1.—Smokejumper descending to jump spot in mountain terrain. Jumper is facing camera. Note two slots in parachute canopy. These are used by the jumper to change his direction. Also air escaping through the slots propels the airborne jumper forward in the direction he is facing.

Terrain and soil, insofar as these affect availability of suitable jump spots within acceptable distance from fires.

Cover.—Unbroken areas of heavy windfall and snags or of certain timber species and age classes may make jumping unduly hazardous.

Weather.—Consistent high winds or turbulence may cause undependability of jumper attack when such air conditions make parachuting highly dangerous.

Given acceptable conditions in these four factors, further planning will include studies to determine size, organization, and location of crews by calendar periods, equipment complement, type of aircraft, etc. Analysis of fire occurrence and behavior is the best basis for calculating probabilities in fire fighting work load, both gross volume and distribution by areas. Given similar conditions, this phase may be greatly simplified by drawing on the experience of an existing unit in such factors as average manning, time away from base per fire jump, etc., and applying these to expected occurrence.

Lacking similar conditions, planners are advised to study carefully individual fire records over an extended period and tabulate, for each fire, their best judgment of hypothetical smoke-jumper action in terms of (1) distance of fire from road or airport; (2) number of jumpers required; (3) time and date they would leave base; (4) time, date, and method of return to base; (5) ground reinforcement action, if any; (6) extra flying required for supply of jumpers or ground crew, if any; (7) date and method of return of jumper gear.

When assembled and charted, this information is used to determine probable seasonal loads and the requirements in (1) number of jumpers to meet peak fire loads; (2) jumper equipment: amount, frequency of use, rate of return from field; (3) number of aircraft by type by periods for outgoing traffic; (4) trucks, packstock, helicopters, and fixed-wing aircraft for return of men and equipment; (5) base facilities and airfields.

For most proposed operations, planners will find that economics do not permit smokejumper organization on a scale to care for worst probable situations because such situations occur too infrequently. They then compromise upon units of sufficient size to handle loads at some practicable level below the worst probable peak, planning to supplement smokejumper action by other methods of attack as needed. Smokejumping units are relatively limited in ability to expand on short notice as critical seasons develop, and this characteristic forces preseason commitment as to size of unit. This handicap is, of course, due to the degree of advance preparation involved—specialized, expensive, and time-consuming training and equipment procurement.

However, on the credit side, mobility and wide range of quick striking power greatly increase the potential coverage per man in terms of area protected or fires manned. These characteristics also permit unprecedented pooling of first-attack manpower, in effect, and widespread use of jumpers as needed without regard to regional or other unit boundaries. As an example, it is not un-



F-470019

FIGURE 2.—Army and Forest Service records show that feet, ankles, and lower legs are critical points in prevention of landing injury, especially for the smokejumper who often lands on rough ground. Careful selection and conditioning of candidates are major factors in maintaining a low rate of injury.

common for a given Forest Service smokejumper to make fire jumps in four separate Forest Service regions during a season. In addition he may also jump to fire in a national park, an Indian reservation or on area protected by a private timber association. Such use tends to reduce the impact of localized highs and lows in fire incidence upon the jumpers, as compared with less mobile ground facilities.

Smokejumping is for young men. Forest Service policy precludes continuation of jumping beyond age 40 and new candidates must be 18 to 28. Weight limits for new men are 130 to 180 pounds in most units, height 65 to 75 inches. Sound physique, good general health, mental stability, and good hearing and eyesight are prerequisites (fig. 2), as are work experience in fire protection and a better-than-average work record. This is important; the pay-off is at the fire and you cannot justify the high investment in a man who does not produce accordingly when he gets to the fire.

The initial basic training of a new smokejumper will cost about \$650, not including any prorated share of such items as base facilities or project overhead. Equipment to outfit him will cost \$475 to \$750, depending on degree to which double equipping is necessary (fig. 3). Some units double equip all jumpers. Equip-



FIGURE 3.—Smokejumper trainee receiving an equipment check prior to loading into the airplane for a practice parachute jump.

ment first cost may of course be amortized over a period of years, depending on established service life of individual items.

Aircraft of proper type and number for the particular operation is a key factor. Smokejumping aircraft are also readily fitted to paracargo work. In most areas of heavy smokejumper activity the extreme peaks in jumping and paracargo demands do not ordinarily coincide and heavy dual use of airplanes may be depended upon if they are suitable to both types of missions. Careful study and planning to obtain maximum correlation is well worthwhile.

For large smokejumping areas planners often have a difficult time deciding between centralization and multibasing. Both have certain apparent advantages, some of which may be misleading if not analyzed.

Multibasing: (1) Shorter travel distance to fires; (2) quicker get-away to first call fires, at least; (3) more localized control of dispatching and communication; (4) better opportunities to use men on productive work when not on fire.

Centralization: (1) Greater flexibility in manning; (2) more efficient use of aircraft and other equipment, with proportionate economies; (3) better average elapsed time through ability to take manning action on more fires concurrently.

SIGNAL SYSTEM FOR SMOKEJUMPER AND PARACARGO AIRCRAFT

WILLIAM C. WOOD

Missoula Equipment Development Center, U. S. Forest Service

In the early days of smokejumping and cargo dropping all signals between spotter and pilot were either verbal or manual. Permanently installed bells, horns, buzzers, and lights were used for cargo discharge signals, but until recently, smokejumper spotter signals were made primarily by hand. Voice intercom systems have been used since 1944, but the high voice level and vibrations around the open doors of airplanes in flight made these systems unworkable in most airplanes. Headphones and microphones with connecting wires are cumbersome and restrict movements of spotters and cargo droppers.

In recent years the increasing interregional exchange of airplanes, pilots, and jumpers has shown the need for standardizing the cargo discharge and smokejumper signal system.

The Intermountain Region of the U. S. Forest Service made the first practical use of an electric signal system for smokejumper signals. The unit consisted of red and green lights located in the pilot's compartment and a two-way toggle switch mounted near the jump door. Flashes of appropriate colored light indicated amount and direction of turn needed. Alternate flashing of both lights told the pilot when to cut engine power for jumps. A cargo discharge signal was not an integral part of this system.

The Missoula Equipment Development Center was assigned the project of developing a standard signal system for jumper and cargo aircraft. All Forest Service units engaged in smokejumping and paracargo operations cooperated.

Pilot models of an electric signal device were made up for preliminary field testing. Briefly, these units were small electrical makeup boxes containing red, green, and amber lights energized by flashlight batteries and controlled by toggle switches. A pilot-to-dropper buzzer served as a paracargo discharge signal.

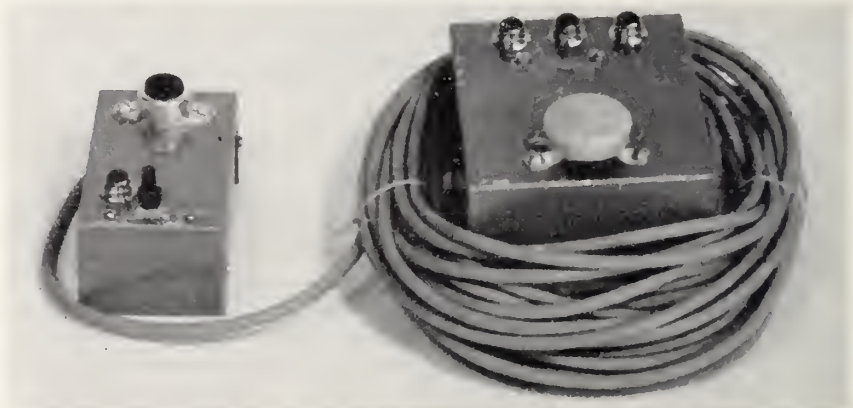


FIGURE 1.—Temporary installation model of the signal system for jumper and paracargo aircraft.

Generally, preliminary test results were favorable. Insofar as possible, suggestions for improvement were incorporated into the final model. The most noteworthy change was in the cargo drop signal where a simultaneously combined light and bell with greater audibility were substituted for the buzzer. Larger makeup boxes were required to accommodate the bell and light assembly. A 6-volt battery was substituted for the flashlight batteries. The overall size of the unit was kept to a minimum.

Field trials of the improved models during the 1957 fire season were satisfactory. Some units favored the use of the light system in conjunction with radio intercom. Others felt the light signal system to be unnecessary where workable intercoms were available. All regions recommended that the signal device be adopted as a servicewide standard for use in contract aircraft where the installation is of a temporary nature (fig. 1).

One suggestion was to replace the cargo discharge bell with a landing gear warning horn. This was not done as it was felt that use of a gear warning horn would be confusing. Many of the jumper aircraft are equipped with gear and stall warning horns as integral safety equipment. Gear warning horns cannot be operated with 6 volts.

At the completion of the field tests, signal light systems were permanently installed in several Government and contract aircraft. These were advantages of the electrical light system:

1. It allows the pilot to do a better and safer job of flying by eliminating the necessity of looking over the shoulder while attempting to fly on course.

2. Better response to signals is possible. With hand signals the pilot cannot keep his eyes on the spotter's hand at all times; consequently, the spotter whose head is out the open door or window frequently signals while the pilot is not looking.

3. More freedom in loading and positioning cargo and jumpers within the ship is possible since an unobstructed line of vision between pilot and spotter need not be maintained. The jumpers can observe the drift streamer without interfering with the signal procedure.

4. The spotter has freer use of his hands during signaling.

5. The pilot can keep both hands at the controls of the ship during the final and critical stages of the cargo approach and can easily signal for the drop by depressing a button. An audible signal gives the cargo dropper greater freedom to make a last minute check of cargo bundle and static line.

6. Temporary installation models can be quickly installed by the pilot or mechanic since no cutting of air frame and no connection to plane's electrical system is involved.

Recommendations.—This light-signal system should be adopted as a servicewide standard for use in contract planes or other aircraft where temporary use is desired. The signal light box should be installed where it can be continuously observed by the pilot as well as where the danger of injury from bodily contact during rough landings or turbulence is eliminated. In the cabin the wiring and switch box should be located where it will not be damaged during cargo loading and dropping, jumping, and other normal activities.

GROUND OPERATIONS FOR HELICOPTERS

JAMES L. MURPHY

California Forest and Range Experiment Station¹

So you're going to use a helicopter? Good idea! Outfits all over the country are finding the helicopter valuable in fire control work. The Angeles National Forest has used a permanent standby ship for the past eight fire seasons. We found that there is a lot of work to be done before the helicopter can take to the air. The following suggestions are a result of our experiences.

ESTABLISHING PERMANENT BASE HELIPORTS

Location.—The most important consideration in planning a helicopter operation is the selection of the base heliport. The base heliport for the Angeles is located at Chilao Fire Camp near the center of the forest. The heliport is at a 5,200-foot elevation—high enough that it isn't an uphill pull to every fire in the forest, yet low enough for safe, dependable helicopter operation. The landing area was constructed on a high point so that a helicopter can always take off or land into the prevailing wind and can drop off into the canyon when taking off.

The Chilao base heliport is large enough to accommodate several ships safely. The landing surface, or "pad," is 75 yards wide and 100 yards long and has an asphalt surface to prevent dust from being picked up by the rotor blasts. The field name, "Chilao," a "North" arrow, and the elevation are painted across the pad to insure positive identification from the air (fig. 1).

Ground operations crew.—All heliports require ground crews. The crew usually consists of an air traffic manager and two or three men. The traffic manager directs air operations and orients and briefs the ground and flight personnel. He is responsible for enforcing safety relations. He also maintains necessary records. The crew helps him load and unload personnel and prepare, weigh, and load cargo. On unpaved heliports, the crew also dustproofs the heliport. Otherwise dust might injure the men's eyes or enter gasoline and oil containers and dispensers in the refueling area. Personnel working at the heliport should wear goggles when the rotor is turning.

Air traffic manager.—The air traffic manager has a big job. He must plan and coordinate all cargo dropping, reconnaissance, and transportation of personnel. He must establish priorities and

¹Maintained at Berkeley, Calif., by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of California. Work covered by this report was conducted while author was employed as Air Officer on the Angeles National Forest.



FIGURE 1.—The Chilao base heliport can accommodate several ships.

schedule all flights, and therefore should be supplied with daily fireline crew assignments and fire maps. He is also responsible for all ground operations at the base heliport, including instruction of all personnel in the safe methods of approaching, loading, and departing from the ship.

The air traffic manager should have full control over scheduling trips from his heliport. Even if the fire boss wants to use the ship away from the base heliport, the air traffic manager should be notified. Any time the helicopter has completed its assigned mission it should be returned to the heliport. If all pilots understand this procedure, it will prevent commandeering of the ship by unauthorized personnel.

Base heliport facilities.—At Chilao we installed an 8-foot wind sock on a swivel and mounted it on a 25-foot section of 1-inch pipe. This wind indicator was placed in a visible spot on the edge of the heliport safely away from the normal takeoff and landing lanes.

All preventive maintenance must be done at the base heliport by the assigned helicopter mechanic, usually at night when the helicopter is not operating. To help the mechanic, we built a work bench and installed an electrical outlet.

High octane aviation gasoline is delivered to the base heliport from a central distributor in large quantities at infrequent intervals. We built a latticework house in which to store the 50-gallon drums of gas. The floor of the house is raised for quick loading of the drums into a pickup truck. Many forests place a

gas supply at several accessible landing spots throughout the forest.

Good communications are vital at the base heliport. We installed a telephone with a loud Klaxon that can be heard above the motor noise of the helicopters.

Safety is important in all phases of the ground operations. The Chilao heliport was posted with "No Smoking" signs. Fire extinguishers were placed at the work bench and at a convenient spot near the refueling areas. To warn curious sightseers, we posted "Danger—Heliport" and "No Smoking" signs across the entrance to the pad.

Helicopter accessory equipment.—The helicopter may be dispatched at any moment during daylight hours. Accessory equipment for any type of mission must be readily available at the base heliport. Inventory lists of kits prepared for the Chilao operation will be provided by the California Forest and Range Experiment Station upon request.

Operational maps and records.—Daily flight-time records are needed whenever a rental helicopter is used. The most efficient system is for both the air traffic manager and pilot to keep a record in pocket-sized field notebooks. At the end of each day the two flight records are compared, and the final entries are made in the permanent flight record.

Most helicopter operators are guaranteed a minimum number of flight hours as a condition of the contract. It is important to the contracting agencies to know whether full use is being made of this time. At Chilao we placed a large bulletin board in the heliport operations shack and displayed two charts. The first chart gave a day-to-day total of all flight time and the remaining time available during the rest of the contract period. The second was a line graph with each date of the contract period as the vertical axis and the total flight time as the horizontal axis. Two lines were plotted on the graph. The first was a uniform slope line of expected flight time, and the second was the fluctuating line of actual flight time. By comparing the actual with the expected, we could see how quickly the time was being used.

Helicopter operation map.—A master helicopter operation map of the Angeles National Forest was started in 1956. It was made from small-scale topographic maps of the 15-minute series and was displayed on the bulletin board. To be useful the following information must be current and accurate on the map: Aircraft hazards, such as utility lines; areas of extreme air turbulence; helispots and field heliports approved by the pilot; flight time from the permanent base heliport plotted by circles in 5-minute intervals.

ESTABLISHING SEMIPERMANENT FIELD HELIPORTS

Location.—Here are some important points to consider before selecting a field heliport:

1. Accessibility to men and supplies or to the fire camp.
2. Presence of hazards such as power lines.

3. Location so that a drop-off can be made *into* the prevailing wind.

4. Area level and free from all obstructions.

5. Higher than surrounding ground so that men approaching and leaving the ship will be well below rotor-blade level.

6. Accommodations for several ships (each small helicopter requires about 2,500 square feet).

7. Should be fireproof.

Field heliport operation.—Once the field heliport has been selected, ground operations must be established. When the helicopter was dispatched to a fire from the Chilao base heliport, the mobile base heliport kit was sent at the same time on the helicopter maintenance truck.

The ground crew should stockpile a good supply of fire tools, water, and other items at the heliport. The storage area should be at least 100 feet from the landing spot for maximum safety.

Communications also are an important part of field heliport ground operations. Radios are a must. Telephones may be installed but they are not always adequate. Helicopter-to-fireline communications are necessary to coordinate cargo drops. It is also imperative that the air traffic manager be in contact with the pilot while the ship is in flight. It may be necessary to ground the ship while other low-flying aircraft are in the area. This can be done only by radio.



FIGURE 2.—An ideal field helispot offers a 360° choice of takeoff and landing direction. The vegetation is cleared well below the level of the landing area, and the touchdown pad is level and free of obstructions.

TEMPORARY HELISPOTS

Specially needed helispots can be built at key locations requiring very little improvement. The pilot should select these spots and then give instructions and the location to the crews on the ground by radio or a dropped message.

Helispots must furnish takeoff and landing choices into the prevailing wind (fig. 2). For small helicopters, they should be about 50 feet in diameter and fairly level with no obstructions. A 15-foot square touchdown spot may be elevated to raise the rotors to a safe height above personnel. A wind indicator must always be placed as close to the actual landing spot as is safe.

SUMMARY

Helicopter ground operations demand considerable planning and work. Permanent base heliports must be located, constructed and equipped for efficient, fast, and safe action. Semipermanent field heliports call for expert location and close supervision of ground operations by a trained ground crew. Temporary field helispots located at strategic spots on the fireline in response to a momentary need present special hazards because of less supervision and control.

Experience during the past few fire seasons on the Angeles National Forest has shown that well-planned and well-executed ground operations are essential for the efficient and successful use of helicopters.

THE HELICOPTER FLIES HIGH

JOY BALDWIN

Fire Staff Officer, Gila National Forest

The Gila National Forest of Region 3 sprawls across the Arizona-New Mexico State line, the Mogollon Mountains and the Black Range, which is also the Continental Divide in this part of New Mexico. The forest is just short of being 3 million acres in size. The Gila Wilderness Area—the first wilderness area created in the United States, the Black Range Primitive Area, and a part of the Blue Range Primitive Area are within its boundaries.

In this area fire occurrence is thought to be the highest of any such roadless area in the United States. Lightning is responsible for 95 percent of the fires which concentrate in number during the critical period between May 15 and July 15 and occur in lesser numbers in the pre- and post-season.

As an example of concentration density at one time in 1956, men were actually working on 109 going fires. These fires, all lightning-caused, were in the highest and most inaccessible country in the Mogollon and Black Range Mountains in New Mexico and that part of the Mogollon Rim extending into Arizona. Elevations range from 6,500 feet to more than 10,000, with very high fire occurrence in the range of 6,500 to 8,500 feet.

THE PROJECT

The Gila uses a combination of aerial and ground fire organization with each being assigned a given hour-control zone for initial attack purposes. The zones are not rigid in that each group assists the other as needed, or when one group is occupied—whether ground or aerial—the other covers or reinforces it. Some 2 dozen initial attack ground stations are used, and a crew of 18 smokejumpers is based at Silver City.

But there was deficiency in this initial attack organization. It was a common occurrence to have all jumpers out on fires with no way of moving them back in less than 12 to 24 hours; they had to come back on foot. This also involved using one of our ground control men and mules to pack out equipment (average 105 pounds per jumper). The men could have been used for initial attack purposes. Three possibilities of overcoming some of this deficiency were considered: (1) Increasing the number of men and ground stations; (2) enlarging the smokejumper crew; and (3) finding a rapid means of retrieving jumpers and equipment from the back country.

The increase in men in the back country was eliminated as a possibility because we are unable to obtain men properly qualified in the use of livestock who are willing to go in and stay there. Economics also entered into this decision. It would be

hard to keep such men gainfully employed even if they were available; horses and mules are scarce, and feed for the animals is extremely expensive to either pack or airdrop. Thus we chose the third possibility and elected to try the helicopter.

All of the people in our organization with helicopter experience, as well as people in the helicopter business, helped in the preliminary planning, and specifications by helicopter manufacturers were examined. After analysis of performance requirements to meet difficult high-altitude and high temperature conditions, a late model 3-place helicopter was chosen. This helicopter was provided by a commercial operator under a bid contract.

RESULTS TO DATE

The following summary of helicopter use in 1957 speaks for itself:

1. 128 jumpers were retrieved from 64 fires. As mentioned earlier, walkout and return to base of smokejumpers is anywhere from 12 to 24 hours, and other personnel is tied up retrieving them. Conservatively, use of the helicopter saved 12 hours per smokejumper or a total smokejumper time of 1,440 hours. The big advantage, of course, is in having the jumpers available to meet another possible fire emergency.

- On one fire, when all jumpers were out, the helicopter made it possible to retrieve 4 jumpers to jump on another fire in the wilderness area. The 4 men plus 3 others, 2 of whom were jumpers walking in, were able to control a fire at 20 acres. It took approximately 17 hours to get assistance to this force by ground. Possibly several thousand dollars was saved in this particular case.

2. 16 jumpers built 18 helispots and, with the exception of 4, all were built by smokejumpers without assistance from other personnel. Without the "chopper" to retrieve the men, we could not have advanced so rapidly in our program.

3. On one fire 11 firemen were returned to their cars by "chopper" at a savings of 3 hours per man. The important thing was that the men were immediately available for other fires had they occurred.

4. Four men put on 2 fires by helicopter for initial attack saved about 2 hours each and, in addition, both fires were held to small B size. Otherwise, additional men would have been required 2 hours later and damage would have been much greater.

5. One rescue mission—injured lookout. This mission would have required the jumper plane for 2 hours, 8 men for 10 hours, and 1 ambulance for 80 miles. The "chopper" did the job in 1 hour, thus alleviating a great deal of suffering for the injured man. We were not exposed to a major disaster by tying up our smokejumpers and plane.

6. 13,126 pounds of freight, the equivalent of 88 mule loads, were hauled for fire suppression; 480 man-hours and 704 mule-hours were saved.

7. One emergency repair to remote radio equipment with radio technician.

8. Three reconnaissance flights selecting helispots.

9. 330 flights were made in the helicopter from altitudes of 6,000 feet (home base) to 9,300 feet over a wide temperature range. Landings were as follows:

<i>Altitude (feet)</i>	<i>Number</i>	<i>Altitude (feet)</i>	<i>Number</i>
5,501-6,000	78	7,501-8,000	56
6,001-6,500	2	8,001-8,500	41
6,501-7,000	30	8,501-9,000	0
7,001-7,500	107	9,001-9,500	1

Payload had a wide range depending on altitude and temperature; however, a general average of 200 to 220 pounds was handled at 7,500 feet and up to 350 pounds at 6,000 feet.

MISCELLANEOUS

One standby crew was placed in an isolated, very high occurrence area. All supplies were by plane, and the parachutes plus remnants were returned by helicopter.

During the 1957 season, the Packsaddle, McKenna, Turkey, Rocky, White Creek, and Flare Fires were all potentially dangerous and gave much trouble to initial attack forces. The helicopter, through all uses, played a major role in preventing one or more of the fires from becoming project size.

THE LOOK AHEAD

During 1957 a study was started to determine what upper limits of altitude are imposed by temperature and turbulence at any given time. The test is continuing and we hope to establish a few spots in 1958 that will permit more testing at altitudes from 8,500 to 10,000 feet. When completed, we will be able to determine density altitude for a particular location and from a conversion table, we should be able to safely state what performance in load may be expected. The testing in marginal altitudes is to be done in a safe and prudent manner, and under no circumstances do we intend to experiment where life or property is placed in jeopardy.

New developments in rotary wing aircraft are coming rapidly, and helicopter limitations as they exist today are being so rapidly overcome that it is hard to visualize all we may be doing with these machines in the future.

FIRE ACCESSORIES FOR THE LIGHT HELICOPTER

Arcadia Equipment Development Center, U. S. Forest Service

Many who have flown over and around fires in a helicopter have thought, "If only I could drop a couple of gallons of water on that spot," or "these 'copters are terrific, but there must be other things we can do besides haul men and sightsee." Well, we now have an equipment system which will do four basic fire jobs with the speed and mobility that is inherent with a helicopter. They are (1) bulk drop 35 gallons of water or chemicals, (2) lay up to 1,000 feet of 1½-inch fire hose, (3) transport a lightweight pumper outfit complete with hose and water, and (4) deliver other cargo with a simple dual sling, electric-release device.

This equipment has been developed at Arcadia as part of the joint Air Attack (helitack) Program being conducted in cooperation with the U. S. Engineers, California Division of Forestry, and Los Angeles County. The aim of this program is to exploit the potential fire fighting abilities of the helicopter.

What started out as one piece of equipment has developed into a family of accessories designed around a standard carrying device.

Bomb shackle adapter assembly.—The heart of all attachments is an assembly (fig. 1) using a standard Navy bomb shackle (1,600-lb. capacity), fitted with an external solenoid release. A manual cable release D-ring is also provided the pilot for emergency use in the event of electrical failure. The entire rack weighs 29 pounds, quickly clamps to the cross-tubes beneath the helicopter, and is fitted with slip joints to allow for dimensional differences. It is constructed entirely of 4130 steel rectangular aircraft tubing.

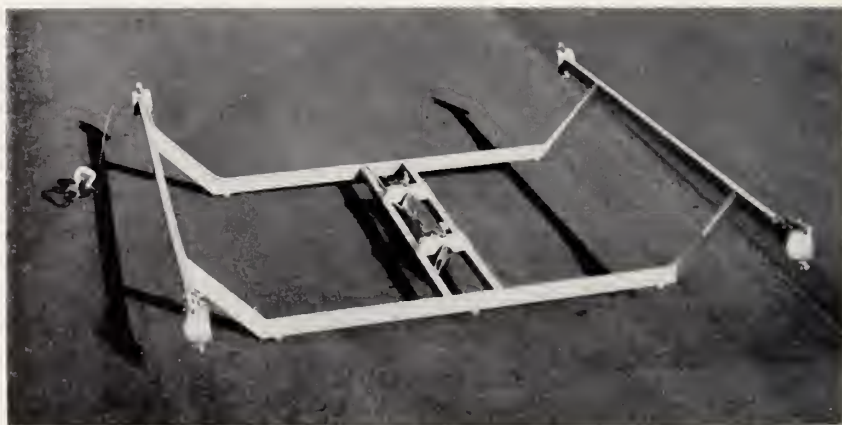


FIGURE 1.—Bomb shackle adapter assembly.

Some operators have wired the 24-volt solenoid directly to the dust hopper release button on the cyclic control stick, thus providing an instantaneous operation of the shackle.

The assembly has been CAA certified for use in an unrestricted category when not carrying accessories.

Helitank.—An accessory which has proved itself on fires during the past season is the helitank (fig. 2). The tank shape evolved from the standard pyramidal shape of the canvas relay tanks and is designed to be self-supporting while the tank is being filled on the ground. The 35-gallon capacity was selected to limit the load to a reasonable amount for operation under marginal flight conditions at high altitudes and temperatures. The tank is made of lightweight neoprene-coated nylon fabric and weighs $4\frac{1}{4}$ pounds. Certain dimensional limitations were maintained so that loading operations can be done underneath the helicopter and to keep sling length as short as possible.

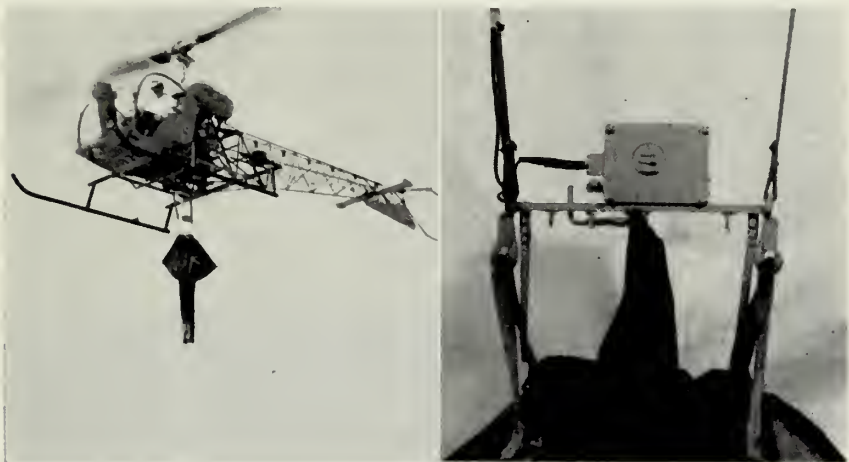


FIGURE 2.—*Left*, Helitank dropping 35 gallons of water. *Right*, Helitank sling release.

Several snout release methods were tried; the one selected consisted of turning the snout inside-out and suspending it up through the tank. As a result, the fastening is centrally located and better accuracy is provided by the discharge of water straight down when released.

The tank is suspended by nylon straps on a short spreader bar equipped with two parachute snaps on the ends. This bar in turn is attached to the bomb shackle by short web slings, and is equipped with a pin release in the center, operated electrically by a 24-volt solenoid (fig. 2).

This solenoid can be activated from the radio button on the cyclic stick, or it can be wired through a small switch taped to the stick and powered by a battery taped to the adapter. Grommets are located in the end of the drop snout of the tank through which the pin passes, thus holding the snout above the tank during flight prior to the drop.

In operation, the tank is placed inside the skid on the ground and hooked up to the sling release. Filling can be accomplished in this position, or the helicopter can land over the filled tank. It has been found practical to land over the filled tank when returning with an empty unit, and disengaging and taking off with a full unit in less than one minute. After setting up the operation, a marker or line alongside the skid on the ground will spot the ship exactly for hooking up. On one fire operation utilizing a pair of tanks, drops were made $\frac{3}{4}$ of a mile away by one helicopter every 4 minutes.

At 15-25 m. p. h. a good wetted area is obtained about 10-15 feet wide and 50-75 feet long. The pattern is of course shortened as speed decreases. Excellent coverage on single snags has been obtained. It is not normally safe to hover above fires because of rotor blast.

Since the sling is suspended from the bomb shackle, the pilot has the safety feature of being able to jettison the entire sling and tank in an emergency.

Fire hose dispensing tray.—A tray, approximately 4 by 8 feet, which can hold up to 1,000 feet of packed hose can be easily attached to an H-bracket which in turn is rigidly secured in the bomb shackle. The H-bracket weighs 15 pounds, and the tray 30 pounds. The same sling assembly used for the helitank can be fastened on the tray for electrically dropping a roll of hose which in turn starts the folds of hose in the tray flaking out while the helicopter is in flight. (figs. 3 and 4).



FIGURE 3.—Packed hose tray ready for flight.

The horseshoe pack minimizes center-of-gravity changes and permits smooth discharge. The hose is also tied in the tray at the forward end in sections with 21-pound break-away thread to prevent discharging in bunches.

Normally the tray is removed by lifting it out of the parachute snaps and sliding it from underneath the ship. In event of an emergency, tripping the bomb shackle lets the H-bracket and tray fall free.

Flight speeds of 10 to 20 m. p. h. were found to be the safest, although ground test studies have been safely conducted up to 50 m. p. h. An early model hose tray was flight tested by a helicopter manufacturer at maximum allowable center-of-gravity limits and it was found that helicopter controllability was well within the allowable range.

The first use of this hose lay method on a going fire occurred July 5, 1956, on the 400-acre Sterling Fire, San Bernardino National Forest, when 1,000 feet of hose was laid on the northwest edge of the fireline.

Electric sling cargo release.—Helicopter flight tests have shown that cargo slung beneath on a single point tends to oscillate and rotate causing unbalanced forces. The use of a double sling largely eliminates the fore-and-aft center-of-gravity changes in takeoff



FIGURE 4.—Hose lay by helicopter.

and landing. The sling release, therefore, has been equipped with release arms that can electrically drop two cargo lines simultaneously (fig. 5). Although the bomb shackle can be used for handling cargo, it is somewhat inconveniently located for fast accessibility, while the sling release is handled off to the side beneath the helicopter.

The release arms do not impair operation of the release pin when used with the helitank. Thus the sling serves three purposes: Starts the hose lay, operates the helitank, and carries cargo. The prototype model has been load tested to operate at 1,050 pounds. Again, the pilot can jettison the entire cargo sling should the release arms fail.

Helipumper.—This useful piece of cargo was developed for helicopter transport. The unit consists of a lightweight portable pumper (7.5 gallons per minute at 150 pounds pressure per square inch), 200 feet of 1-inch lined hose, and a water hopper which can hold a pair of 5-gallon metal or disposable cardboard water cans for initial delivery (fig. 6).

In operation the hose is coupled to the pump, the pump started, and water poured into the hopper tank. A pressure relief valve is provided in the system to bypass the water when the nozzle is shut off. The helicopter can stockpile or supply water in cans or boxes by using the cargo sling release. Delivery of helipumper and water may thus be accomplished without landing.

Overall dimensions of the unit are low to permit placement on the ground inside the skid. This again keeps sling length as short as possible. Full weight of the unit is 187 pounds, empty 63 pounds.

Other equipment.—After using some of this equipment on fires, it became apparent that the speed of attack was sometimes lost as a result of slow delivery to the heliport. Calling the warehouse

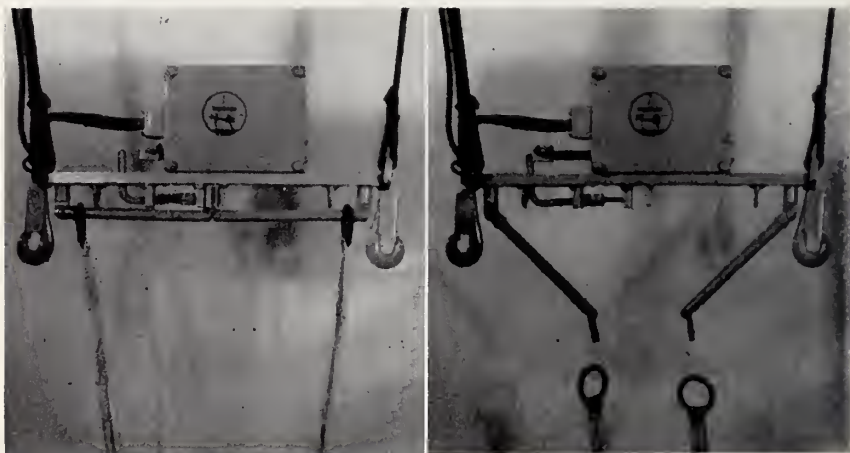


FIGURE 5.—A prototype design of a dual release attachment on the sling showing cargo lines in place and released.

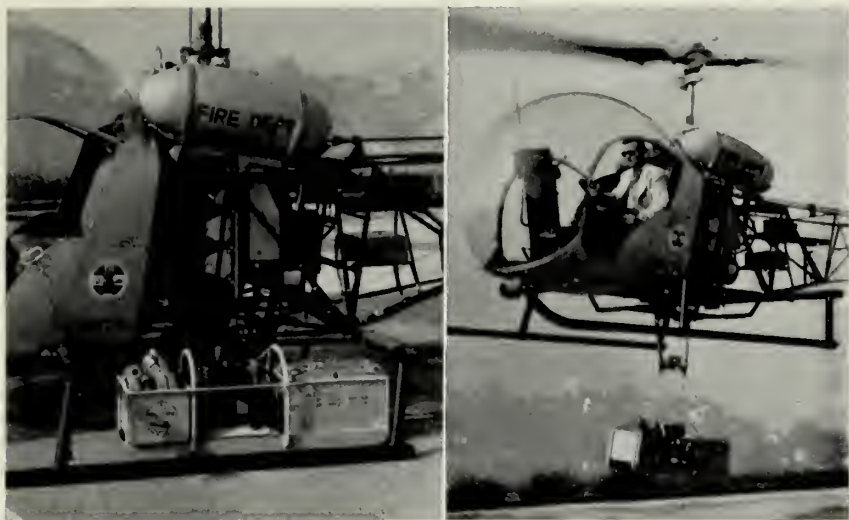


FIGURE 6.—Helipumper unit: *Left*, In position inside skid; *right*, being delivered.

and then waiting several hours for delivery cancels the entire potential speed advantage. To solve this problem the project has scheduled design of a truck-mounted slip-on, equipped with all the accessories and servicing tools so that it can be promptly dispatched to the flight scene. With the adapter assembly permanently mounted on the helicopter the accessories can be hooked up in minutes.

THE HELICOPTER JOINS THE HOSE-LAY TEAM

FLOYD W. WAKLEE, *Forestry Equipment Engineer, California Division of Forestry*; HERB SHIELDS, *Mechanical Engineer, Arcadia Equipment Development Center*; CARL C. WILSON, *Chief, Division of Forest Fire Research, California Forest and Range Experiment Station*.

The helicopter proved it could lay fire hose over brush rapidly and safely in 1956.¹ Additional tests conducted in 1957 showed that it can do the job over timber and other cover types, and revealed some of the work still needed to make this versatile tool even more effective.

The 1957 tests,² carried out at Sorefinger Point near Weimar, California, covered three specific methods. First, we checked the time and performance of a ground crew making a 2-mile lay by hand; next, the ground crew did the job with a helicopter assist; finally, the pilot alone laid the hose from the helicopter.

Hose lay by hand.—A specially trained 6-man crew of the California Division of Forestry was used. Each man in the crew carried 200 to 300 feet of hose in conventional pack sacks, and the only assistance received was 5 hose deliveries by truck.

We found that a 2-mile hose lay by a small crew isn't the "impossible" job we had visualized. The 6-man crew took only 2 hours and 55 minutes to lay 10,900 feet of 1½-inch hose over the 10,819-foot course. This time included delays of 4½ minutes while the crew waited for hose deliveries by truck, 5 minutes while killing a rattlesnake encountered en route, and 23 minutes lost because part of the crew had to walk back uphill to get more hose. Thus, net time was only about 2 hours 22 minutes.

For the first 4,728 feet, the crew laid hose at an average of about 100 feet a minute. Fatigue began to show at about 47 minutes from starting time, and the men became increasingly tired as they fought through heavy brush. In spite of fatigue, with a brief rest this 6-man crew would still have been an effective suppression unit even after laying 2 miles of hose.

Hose lay by hand with helicopter assist.—During this phase of the tests 1,200 feet of hose was attached to a cartridge for dropping (fig. 1). In a preliminary test, the hose package was jettisoned from 60 feet by the pilot. The hose fell into a clump of brush and rolled across a rock-covered slope. The cartridge was so badly bent that it had to be repaired before further use. In addition, one length of hose was cut. The remainder of the hose was tested at 350 p. s. i. and found okay. Damage to the couplings was negligible.

¹*Improved Fire Hose Dispensing Tray for Helicopters.* Arcadia Equipment Development Center. U. S. Forest Service Equip. Devlpmnt. Rpt. 44, 26 pp., illus. 1956. [Processed.]

²*The Helicopter—A New Member of the Hose-Lay Team.* Waklee, Floyd W., Shields, Herb, and Wilson, Carl C. U. S. Forest Service Calif. Forest and Range Expt. Sta. Res. Note 129, 11 pp., illus. 1957. [Processed.]



FIGURE 1.—A package of 1,200 feet of 1½-inch fire hose attached to cartridge and ready for installing on adapter assembly of helicopter.

After dropping 3 loads (3,600 feet of hose) at preselected spots, we called the operation off because of excessive hose damage. Several couplings were damaged, and 7 lengths of hose were ruptured or cut by the impact as the 300-pound load and the cartridge hit the ground. The two men who fitted the hose package to the helicopter found that there wasn't room to work under the helicopter and the cartridge straps were too short to allow any freedom. If this method is to become practical, we need to develop a way to package the 1,200-foot hose cargo so that it can be jettisoned from a helicopter 75 to 100 feet above the ground without damaging the hose or couplings.

Helicopter hose lay.—We then made the entire lay by a helicopter with the hose-lay tray. To speed up the operation, hose was prepackaged on plywood sheets and stockpiled at the heliport ready for immediate use. At first, the tray of hose was delivered by having a man on the ground start the lay by grabbing the dangling hose as the helicopter hovered overhead. But in timber stands, the cover was so thick the pilot could not hover close to the ground, and the other lays had to be started by the pilot (fig. 2). He released a 100-foot coil of hose tied to the skid gear, and the weight of the coil pulled the hose out of the tray.

Prepackaging the hose on plywood transfer pallets partially solved the problem of loading the helicopter hose tray. We still need better ways to strap the hose package to the plywood and tie the sections to the tray, but these problems can be solved by equipment development.

We found that the helicopter using the hose-lay tray can lay fire hose over gentle to steep topography and above brush and light timber. The key was in finding a way for the pilot to start



FIGURE 2.—Hose lay started by pilot. Hose pays out over tops of oaks and pine trees.

the lay at his convenience—using a length of hose for a weight.³ Total time for the 2-mile lay by air was 2 hours and 29 minutes, including 42 minutes lost because of mechanical problems—26 minutes less than was required by the hand crew. Although 4 men were used to connect the hose when it reached the ground, they said that 2 could have done the job.

We also learned that the helicopter lay takes much more hose over timber and heavy brush. It required 12,570 feet, compared with 10,900 feet for the hand lay—about 16 percent more. Hose laid from the air catches in the tops of trees and drops down between them. We found that the extra 100 feet of hose used to start the lay is useful for splicing when the hose sections don't quite come together. This extra length could also be helpful for replacing ruptured lengths in a long lay.

Another point learned was that reduced airspeed during the hose-lay operation is important. The pilot should never fly faster than 20 and preferably between 10 and 15 miles per hour.

The pilot told us that the lay would have progressed faster and with a wider margin of safety if he had been able to contact the ground crew by radio. Not only can the ground crew be unaware of special hazards visible from the air, but also the pilot may be unable to see ground hazards. Ground-to-air and air-to-ground communications are as vital for helicopter hose lays as for other aircraft operations.

³An electric device for releasing the 100-foot (25-pound) coil of hose to start the hose lay is reported in *Fire Accessories for the Light Helicopter* in this issue.

TRAINING THE HELITACK CREW

JAMES L. MURPHY

California Forest and Range Experiment Station¹

"Help!" the voice on the radio screamed, "I'm trapped, the fire's all around me!" The year, 1947; the fire, the Bryant Fire on the Angeles National Forest in southern California. The situation: a radio operator running an emergency radio relay station on a remote ridgetop was in the path of a blowup. Five minutes after his call, he was safely off the mountain. The helicopter had made its forest fire debut.

The helicopter is now a common forest fire-fighting tool in California. Its value and effectiveness are beyond question. But the helicopter is not an ordinary fire tool. It is expensive and is potentially as dangerous as it is valuable.

To obtain the safest and most efficient use of the helicopter the Helitack program² has included the organization and training of Helitack crews. In 1957 almost 300 fire fighters from 12 national forests, the California Division of Forestry, and the Los



FIGURE 1.—The San Bernardino National Forest base heliport is accessible by road, has a drop-off into the prevailing wind, and has an asphalt touch-down pad.

¹Maintained at Berkeley, Calif., by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of California. Much of the work included in this report was conducted under terms of a cooperative student-aid agreement between Utah State University and the experiment station.

²A cooperative research and development program of the U. S. Army, the California Division of Forestry, and the U. S. Forest Service.

Angeles County Fire Department were trained in helitactics. An outline of the training plan follows.

- I. Organization and qualifications of the Helitack Crew
 - A. Helitack foreman: Qualified as sector boss (U. S. Forest Service fire rating) and experienced in air operations on forest fires.
 - B. Assistant Helitack foreman: Qualified as crew boss and experienced in air operations on forest fires.
 - C. Helitack crew member: Must have two seasons of fire experience.
 - D. Helicopter pilot: Must be an experienced mountain pilot.
- II. Ground operations
 - A. Locating permanent base heliport (fig. 1).
 - B. Installing base heliport facilities.
 - C. Safety regulations.
 - D. Equipment kits.
 - E. Preparation of helicopter operations map.
 - F. Flight and other records.
- III. Training the Helitack Crew
 - A. Pilot training.
 1. Helicopter-use policies not included in general CAA instructions. (One source is the Region 5 Supplement to the National Forest Manual for Forest Service Use Policies and Working Instructions.)
 2. Fundamentals of fire behavior.
 - B. Crew training.
 1. Safety.
 - a. Precautions while on ground
 - (1) Keep at least 50 feet from helicopter at all times unless job designates otherwise.
 - (2) Dustproof all landing areas by wetting down or oiling. Wear goggles at all times when helicopter is at heliport.
 - (3) Approach and leave helicopter from the front so that pilot can see you at all times.
 - (4) Do not approach or leave helicopter over ground higher than that on which the ship is standing.
 - (5) Keep clear of main rotor and tail rotor. Watch long-handled tools.
 - (6) Provide a wind indicator at all landing spots.
 - b. Precautions before takeoff.
 - (1) Obtain pilot's approval on all missions.
 - (2) Check wind conditions. (Helicopters should never be dispatched for mountain flying when average wind velocity over a 5-minute interval at exposed peaks is more than 30 m. p. h.).
 - (3) Fasten and adjust safety belt.
 - (4) Keep clear of controls.
 - c. Precautions while in the air.
 - (1) Keep safety belt secured until pilot signals release.
 - (2) Keep oriented at all times.
 - (3) Watch for special hazards.
 2. Job familiarization.
 - a. How the helicopter works.
 - b. Maintenance and use of all Helitack equipment.
 3. Development of skills.
 - a. Physical conditioning.
 - b. Refresher course in fire behavior, use of tools, and line construction.
 - c. Map reading and use of compass.
 - d. Forest Service ground-to-air visual signal code.
 - e. Use of radios.
 - f. Hover-jump (dropping from ship hovering 6 to 8 feet above ground) training:
 - (1) Protective suit.

- (2) Jumping procedure.
 - (a) Make a high-level pass to determine general area safest for jump.
 - (b) Make a low-level pass and pick the jump spot.
 - (c) On third pass, at pilot's signal, drop tools near jump spot.
 - (d) On fourth pass, jump in compliance with established procedures (fig. 2).
- g. Hover-landing procedure.
- h. Helispot location and construction. (One of the big responsibilities of the Helitack Crew.)
- i. Fire suppression procedure.
 - (1) Initial attack on small fires.
 - (a) First response, pilot, Helitack foreman, one crewman.
 - (b) Reconnaissance of the fire.
 - (c) Crew landing.
 - (d) Initial attack.
 - (e) Helispot construction.
 - (2) Large fire procedure (where Helitack Crew will not make initial attack).
 - (a) First response: pilot, Helitack foreman, one crewman.
 - (b) Ground response: remainder of crew with Helitack Crew equipment.
 - (c) Heliport location: foreman and pilot.
 - (d) Traffic management: Helitack foreman.
 - (e) Operation of base heliport: Helitack crew.
4. Standby duties: prevention, presuppression, insect and disease control, search and rescue, aerial seeding.

Experience during the past 10 years on California forest fires has proved that safe and efficient helicopter operation requires a specialized crew well trained in every use of helicopters on forest fires. This training can pay big dividends in cutting fire fighting costs and reducing overall damages.



FIGURE 2.—At the pilot's signal, Helitack crewman grips both sides of the open door firmly. He swings his right foot out to the skid. His lower right leg and knee are placed snugly against the skid gear leg.

HELITACK CREWS PAY OFF IN CALIFORNIA

JAMES L. MURPHY

California Forest and Range Experiment Station¹

"Catch 'em while they're small" has been the goal of forest fire fighters since the beginning of organized forest fire suppression. Even the largest and most disastrous fires could have been stopped in their early stages had a few experienced men been able to reach them and take immediate action. Early detection and fast, efficient action are the only practical answers to successful initial attack.

The helicopter, introduced to California fire fighters in 1947, has shown promise in reducing the time interval between detection and initial attack. But helicopter use can be expensive, particularly if not closely supervised. We also know it can be dangerous to anyone not aware of its hazards.

HELICOPTER SPECIALISTS

A team of specialists, highly trained in using helicopters on fires, may offer a solution to these problems. This was demonstrated in 1954 when the Angeles National Forest organized a 4-man crew of specialists trained in initial attack by helicopter, in location and construction of helispots, and in air operations on large fires.

Limited experience indicated that this type of crew could become an important part of the fire suppression organization. Consequently, when Helitack was organized in 1956,² one of the objectives was to study the use of crews in performing certain specialized fire jobs with helicopters. California was selected for the training area. During the 1957 fire season some 300 fire fighters from the national forests, the California Division of Forestry, and the Los Angeles County Fire Department were trained in "helitactics."

USE OF HELITACK CREWS, 1957

In 1957 Helitack crews were used in a variety of ways in California. They made 42 initial attacks throughout the State, controlling 32 fires in the early stages with no other aid. On five

¹Maintained at Berkeley, Calif., by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of California. Much of the work covered by this report was completed under terms of a cooperative student-aid agreement between Utah State University and the experiment station.

²A cooperative research and development program of the U. S. Army, the California Division of Forestry, and the U. S. Forest Service to integrate helicopters into fire suppression activities.

fires the Helitack crews were helped by another new fire tool: air tankers. On four other fires the Helitack crews were soon joined by ground or smokejumper crews who aided in suppressing the fires. Only once was a Helitack crew unable to stop the fire in initial attack.

Average travel time for the Helitack crews was 33 minutes, including flight time from the company base for those helicopters not on standby contract. Followup ground crews averaged 3 hours and 48 minutes travel time. The effectiveness of such fast initial attack is evidenced by the report of the fire boss of the Ditch Fire on the San Bernardino National Forest: "Helitack crew made initial attack, knocked down head and hot-spotted flanks."

Where the Helitack crews could not control a fire on initial attack, they paved the way for fast followup crews. This type of operation was reported on the Pate Fire on the Los Padres National Forest: "Fire in inaccessible area on ridgetop. Crew made hover-jumps near the fire and constructed helispot. Relief crews, supplies, and equipment were flown in and out by the helicopter. At least 30 acres and \$900 in costs were saved."

OPERATIONS ON LARGE FIRES

The Helitack team of specialists can also perform important jobs on large fires: Reconnaissance and scouting, management of air traffic, maintenance and service of heliports, location and construction of helispots, servicing helicopter accessories, and hot-spotting isolated sectors of the fireline. Helitack crews also proved effective in northern California as mopup and patrol crews on lightning fires following initial attack by smokejumpers.

The Devore Fire on the San Bernardino National Forest demonstrated another ability of the Helitack crew. Their efficiency in packing and installing helicopter hose trays and in helping lay 4,000 feet of 1½-inch hose was a vital factor in bringing the 96-acre fire under control in a brushy, rugged area.

OTHER USES OF HELITACK CREWS

Because of their specialized knowledge, Helitack crews are especially valuable for training other fire fighters in helicopter use and safety. They also aid presuppression programs in other ways. They construct helispots. They increase detection coverage on days of low visibility and high fire danger by serving as observers. At least one national forest said that the helicopter and its crew were a valuable aid in fire prevention work: Once forest users were aware of the helicopter patrol, they remained out of areas closed to public use.

Helitack crews also have been used on nonfire projects, such as detecting and treating insect-infested trees in inaccessible timber areas on the Klamath National Forest.

HOW HELITACK CREWS HAVE PAID OFF

In summary, field reports in California in 1957 showed that the following dividends can be obtained from well-trained Helitack crews:

Safety.—Helitack crews are trained, and can train other personnel, to recognize and avoid helicopter hazards. Helicopter-delivered crews get an aerial view of the entire fire and its hazards, are not fatigued by long hikes and, as a result, are better able to cope with emergency situations.

Versatility.—The Helitack crew can be trained in all forestry uses of the helicopter.

Availability.—Specialized crews with equipment specifically designed for helicopter use are kept available at all times. The assignment of untrained men could result in an inefficient and unsafe helicopter operation.

Efficiency.—Use of the helicopter reduces travel time to the fire. Aerial reconnaissance assures quick, decisive initial action that can result in prompt control.

Economy.—Fieldmen of the agencies participating in the Helitack crew training program estimate substantial savings in suppression costs and more than 15,000 acres saved on 26 fires as a result of Helitack crew activities during the 1957 fire season.

Even with these advantages, Helitack crews must still be viewed as an additional fire tool to be integrated into the overall fire organization. They can be efficient and economical only when used at the proper time and place. They are not intended to replace ground crews, smokejumpers, bulldozers, and fixed-wing aircraft where such units can perform better and cheaper. The next job is to determine the limitations of Helitack crews and to establish guidelines for their use.

INFORMATION FOR CONTRIBUTORS

It is requested that all contributions be submitted in duplicate, typed double space, and with no paragraphs breaking over to the next page.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and unit.

Any introductory or explanatory information should not be included in the body of the article, but should be stated in the letter of transmittal.

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Fire destroys his trees, too



REMEMBER—

ONLY YOU CAN PREVENT FOREST FIRES!

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FIRE CONTROL NOTES

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FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

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Forest Service, Washington, D. C.

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MAKE IT POSITIVE . . . Some Opportunities in Fire Control Training

JACK C. KERN,
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The field of fire management has many opportunities for advancement. One of the greatest challenges, as Show¹ pointed out in an earlier issue of this periodical, is the intensive and specialized development of fire control personnel. But their effective management cannot be passive or taken for granted. Good personnel management requires aggressive and positive direction.

People, the priceless resource of any organization, require understanding, guidance, encouragement, and the chance for full expression of thought and action. Most of us need skilled job leadership and a planned schedule of off-the-job experiences to gain perspective and widen our knowledge.

It has been stated that at least 90 percent of a man's training and development is gained by the man himself under capable job leadership. The remaining 10 percent is gained through formalized group sessions and planned study under skilled instructors. In this whole process of learning by doing and of learning by contact with expert instructors and group thinking, there is practically unlimited opportunity for improvement. However, such opportunity has to be created, recognized as a positive aid to individual and team progress, and worked upon vigorously.

Some possibilities for personnel development follow:

1. The opportunity for positive results by simply taking more "time out for people" is essential. Take time to know people as individuals, and to see how their specific responsibilities fit into the organization. Find out what each of them needs and wants in order to do a good job. Our most successful fire leaders are those who recognize that men need individual recognition and job satisfaction. These leaders seek positive ways to help their men help themselves. They assign the full job, following the principle that people grow when given responsibility. A recent study in five large industries shows that supervisors who continually think about the *people* in their organization actually obtain better results than those who think only of job production.

2. Another important way of learning to know people in the fire organization is to analyze individual training needs. Such an analysis can help prepare the man for top performance on his present job and for future assignments. An individual training plan or personal progress record will make this process of growing on the job more systematic and positive. A simple, written plan prepared by the man and his boss together, enables them to set training goals and to understand their separate responsibilities.

¹SHOW, S. B. *Primary Bases and Ideas for Fire Control Planning on California National Forests*. U. S. Forest Serv. Fire Control Notes 16(1): 1-8. 1955.

ities. Both the employee and supervisor can learn through this process. This plan sets down the man's own ideas of what he thinks he needs to become a better fireman or a better fire leader. The boss may add to these needs, based on his ideas or the suggestions of others who have observed the employee's work. A mutually agreed upon schedule can tell what is needed, and when, where, and by whom training can best be accomplished. Some of this training can probably be done most effectively in a group with a skilled instructor. Good study habits are the responsibility of the individual, but the will-to-do and can-do-it attitudes are often set by the boss.

3. The professional services offered by schools and universities give another chance to improve our training in fire-attack methods and fire leadership. The University of Maryland's College of Engineering, for example, conducts Fire Service Extension Institutes for volunteer fire departments. Three courses of 22 weeks each, involving latest attack methods, are given. They include basic, advanced, and special classes. More and more schools are offering professional help with specialized short courses or workshops. Local fire departments have also developed skill courses for local talent. Such courses are an encouraging contribution to America's growing field of adult education.

4. Fire training committees in mutual-aid organizations, such as those established in the Fire Compacts of the Eastern States, can determine the size and nature of the training job ahead. They bring about a more uniform understanding of fire problems, and of fire organization and control actions. Adding a professional educator or a training specialist to these committees, in an advisory capacity, will help to bring up-to-date teaching techniques to bear upon tough problems of instruction.

5. The assignment of fire training leaders to accompany groups of trainees to going fires has real promise. These group leaders can see that the men are assigned to capable trainers, and that they "learn under fire." Later each man's experiences can be evaluated by the leader and a chart made for future training based on individual need.

In summary, most of us have the capacity to do our jobs better, safer, easier, and cheaper. Most of us have the potential to take on increased responsibilities. Taking time out to analyze ways for self-improvement and the improvement of team efforts can pay dividends. There are opportunities for positive results by the fire man and his fire leader looking at this situation together. The preparation of simple, individual training plans can make both individual and fire-team development more positive and thus more effective. Cooperative action from schools, universities, local educators, and mutual-aid training committees can apply the latest instruction techniques. The assignment of trainees to actual fire situations under skilled leadership can be made more systematic. Fire training is a vital element of good supervision and direction. Its end product is efficient fire service.

SAFE PRACTICES UNDER BLOWUP CONDITIONS—A TRAINING OUTLINE FOR THE FIRE CREW BOSS¹

The purpose of this large fire overhead training outline for the crew boss is to help him know more about blowup conditions and safe practices to use.

Blowup fires and safe practices to follow have always plagued the crew boss. The importance of the problem has again been pointed out by fire accidents during the past several years. There is need for practical, clear, concise instructions to the crew boss on this subject. As a start, the best available information has been listed and recorded in this outline.

A blowup condition is defined as an explosive, violent fire behavior that is difficult to identify before it occurs.

The training outline is organized in three main parts:

- I. Instruction steps and key points to stress in fire behavior fundamentals.
- II. Instruction steps and key points for indicators of dangerous fire behavior (blowups).
- III. Instruction steps and key points for the crew boss to follow for safe practices.

It is extremely important that the instructor use all experiences that can be brought to the attention of the crew boss to point out the key points and principles outlined in this training plan.

It is recommended that a minimum of four hours be given each year to fire crew bosses on the subject of blowup conditions and safe practices.

FIRE BEHAVIOR FUNDAMENTALS

Example of introduction.—Successful fire fighting is based upon the knowledge of why a fire burns and what makes it spread. Fire is simply a rapid chemical combination of fuel, heat, and air. The basic principle of fire suppression is to remove one or more of these elements in the quickest and most effective manner. In order to do this, however, there must be some knowledge of the causes and reasons for fires acting as they do. The primary factors that influence the spread of forest or range fires are fuel, weather, and topography.

¹For the full text of this training guide see *Safe Practices Under Blowup Conditions for the Fire Crew Boss*, by Forest Service, U. S. Department of Agriculture. 19 pp. 1957. [Processed.]

Fuels.—Fuels are commonly divided into two main groups: (1) Flash fuels such as dry grass, dead leaves, tree needles, brush, and small bushy trees; and (2) slow burning fuels such as logs, stumps, deep duff.

Weather.—Weather factors with which you as a fire crew boss will be concerned are wind, moisture, and to a lesser degree, temperature.

Slope or topography.—Slope greatly affects the spread of fire in two major ways: (1) Preheating and (2) draft.

Judgment is the major factor in determining the relative importance of all the elements which determine fire behavior. For example, continuity and arrangement of fuels are sometimes more important than volume. Given a certain volume of fuel, features of arrangement or position will influence spread as well as difficulty of control. If fuels are patchy, broken up by areas of thinner fuel, rocky or barren spots, the spread may be uneven and slow (blackboard illustration recommended). If these same fuels are partly on the ground and partly in the air—standing snags—spread may be by spotting, and with severe winds, this may cause a most difficult fire. *It pays to look carefully at all conditions in sizing up a fire.*

The fire crew boss must take advantage of known methods of sizing up a fire at a given time and predicting what will happen as the fire advances or as changes of weather occur.

INDICATORS OF POSSIBLE UNUSUAL FIRE BEHAVIOR

Occasionally a forest fire burns with an intensity that seems far out of proportion to apparent burning conditions. Each blow-up fire raises the question: What can we do to recognize conditions causing extreme fire behavior? How can we predict these conditions in advance? The following on-the-ground indicators should be watched for as they may mark extreme burning conditions that will follow:

A. Fast burning fuels.

1. Unusually dry fuels.
2. Large amounts of fine fuel (grass, needles, moss, etc.) particularly where continuous and on steep slopes.
3. Crown foliage dried by surface fire over large area.
4. Brush and conifer tree foliage after prolonged drought.
5. Concentration of snags.

B. Weather factors.

1. Strong winds blowing.
2. Unexpected calm. May result in winds shifting.
3. High clouds moving fast may result in unusual winds on ground.
4. Unusually high temperatures early in morning.
5. Dust devils and whirlwinds.

6. Thunderheads above or in close proximity to fire usually lead to dangerous downdraft winds. If thunderhead is upwind of the prevailing wind, the danger is greatest.
7. When slope becomes shaded, look out for downdrafts.
8. If a fire is burning near a mountain or glacier (such as Mt. Hood), greater downslope wind velocities will normally occur.
9. Keep an eye on smoke column. Winds may be blowing from different directions above fire. This could result in spot fires outside.
10. Watch smoke column for an increase in wind speeds aloft. This leads to spotting, and gusty wind conditions may also result.
11. Sudden changes in direction and/or velocity of wind when weather fronts move in.

C. Fire behavior (which could lead to a blowup).

1. Spotting ahead of fire or downslope below line being worked.
2. Intense burning inside fireline.
3. Smoldering fires over a large area.
4. Many simultaneous fires starting.
5. Whirlwinds inside fire causing spots and creating intense, erratic burning.
6. Broadcast crown fires in brush or timber.

SAFE PRACTICES FOR CREW BOSS TO KNOW AND USE

The crew boss has two main responsibilities: (a) To obtain an effective, fair day's work from his crew, and (b) to look after the safety and welfare of his crew 24 hours a day to the best of his ability.

After instructing in how to recognize conditions leading to blowup fires, the training leader guides the group into sharing experiences in what safe practices to know and use to prevent injuries or loss of life during blowup conditions. As he puts across the following instruction steps and key points (which are numbered) he should (a) review with group and stress key points, (b) encourage crew bosses to relate actual experiences they have had on a fire to stress key points, (c) relate experiences he has had to illustrate points, and (d) use case histories of disasters or near misses.

A. *STAY ALERT.* Be prepared for safe emergency action. Keep Your Head.

1. Heads up: Look up, look down, look around.
2. See what you look at.
3. Know where the fire is and how it is behaving at all times. If necessary, use scouts or post lookout with proper communication.
4. Know what danger signs to look for, including fatigue. Use your fire behavior know how.

5. Think before acting. Pause, think, then act.
6. Fire fighting is dangerous. Crew boss has a key job. Men are looking to the crew boss.
7. Keep an up-to-the-minute plan of get-away action in mind.
8. Act with decision and promptly when escape action is needed.
9. Remember—a fireline is not usually safe until it is burned out.
10. The spectacular fire may not be the most dangerous. The quiet-looking fire may be the most hazardous.
11. Get weather forecast in morning.

B. *WORK* and *ACT* as a *TEAM*.

1. Gain confidence of crewmen.
2. Keep crew together. Need to do this for clear, safe actions.
3. Use action words: "Come here," "Follow me," "Keep together." The crew boss is the leader.
4. Don't assume anything. Crew bosses have said, "Let's go" and men have gone different directions.
5. Know where all your men are.
6. Men must follow all verbal orders and stick together when orders are given to move out.
7. Have men keep handtools as they may be of value in providing protection.
8. Assign most experienced, mature men for scouting and for lookout when in especially hazardous situations. Arrange for prompt communication.
9. Manage and control your men.

C. *PLAN GET-AWAY*, including escape routes.

1. Crew boss must always have in mind a clear-cut plan of action for fire blowups. Know in advance where you will lead your crew. If necessary, prepare and mark escape route in advance.
2. Let your crew members know you are responsible for their safety.
3. In the event of a blowup, pause a moment and size up the situation. Then think clearly, speak decisively, and act in a calm and deliberate manner.
4. Remember danger potential of timber, brush, and grass fire fighting.
5. Keep crew informed.
6. Keep in mind open places such as rock slides, streams, burned-over places, meadows, alder patches, and gravel bars.
7. One of the safest spots is burned-over area. If needed, dig in.

8. When not possible to get into burned area, remember, men can travel faster downhill or along contour.
Warning—Remember, winds usually blow downslope at night and fires can run rapidly downhill.
9. If necessary to jump through burning edge of fire, have men place hat or coat over face.
10. Caution men: if clothes catch on fire, roll on ground in dirt to put out fire.
11. Do not travel ahead of fires in direction of spread unless you are positive that a safe place ahead can be reached by crew.
12. When not possible to get within burn, pick most open ground available and avoid dense brush, where men can become separated and go astray.
13. After reaching escape spot, check to be sure it is safe from falling trees, snags, rolling logs, or rocks. Try to find a safe vantage point and post lookout.
14. In any brush fire fighting, when working in advance of fire with dozer, build safety strip for retreat.
15. In timber types, sharp ridgetops are good bet to get to if possible.
16. Watch for safer topography, benches in steep country.
17. As last resort, burn out and dig in.
18. When at safe spot, remember suffocation has killed. Have men keep damp clothes over their noses and get next to ground.
19. Where heliports exist, keep their location in mind.

FOREST FIRE SOUND LOCATOR MISSILE

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In Maine, forest fire fighting ground crews have had many exasperating experiences trying to locate lightning strikes in dense woods in remote areas. Often they were close, yet valuable time was lost before the actual tree or small smoldering ground spot was discovered. Many times, when near enough, crew members were able to locate the fire only by a good sense of smell, or spotted the tree while circling through the area. In other instances they were directed by means of plane to ground radio communication, loud speaker from plane, dropped sketch maps, smoke signals, compass bearings, or some other helpful method. Sometimes crews were fortunate enough to travel right to the spot without too much delay, but this did not occur too often¹. No doubt fire fighters in other States have had similar experiences.

A former Maine Forest Service fire warden, Maurice Clark, had a number of these experiences while working as patrolman in the Katahdin District. For some time he had been thinking on how to perfect a mechanical device that could be released from a plane and that would give off an audible sound of sufficient volume to be heard within a range of 500 yards on the ground and thus narrow down the search area. This idea began to take physical shape after many experiments in his home workshop. Satisfied that his rough homemade model had merit, he then decided that an electronic engineer should be consulted and specialized equipment was necessary to meet desired requirements. He also had to find a concern to manufacture and market the item at a reasonable price.

Electronic Technician William Tiffany of Auburn, Me., provided both financial and technical assistance in developing the device. Thus was born the "Forest Fire Sound Locator Missile" from Maurice Clark's original idea. Patent rights have been approved and production started on a limited scale. The total cost is approximately \$265 per unit, complete with parachute.

In general, this missile is an electronic device, with dry batteries and amplifier, encased in a galvanized iron cylinder. It emits a rising and flowing high pitch signal audible up to one mile in densely wooded areas. It is most effective within one-half mile radius and under favorable terrain and woods conditions can be heard beyond a mile.

Specifically, the component parts and features of this unit are as follows (fig. 1): Removable blunt nose section of 16-gage galvanized iron with battery holder for two power pack batteries in a rubber shock mount; a watertight cylinder housing of 18-gage galvanized iron containing an amplifier unit of a sealed transistorized amplifier in an inner shock case; a reentrant sound projector (signal device); a sound dispensary cone of 360°.

¹As a safety factor the department has a firm policy of always sending out fire fighters in pairs to look for lightning fires.



FIGURE 1.—Dismantled missile showing component parts of power pack batteries, transistorized amplifier, relation oscillator, and removable nose section.

The mechanism is positively triggered by jack-type switch either manually or by plane release mechanism. The overall weight is approximately 36 pounds, diameter $8\frac{1}{2}$ inches, and height 38 inches, painted either cab yellow or Chinese red. There are two hooks on the outside for attaching the parachute, two hooks for provision of a slide bar to simultaneously release the missile from a specially designed carrying rack and trigger the mechanism, and two clamps to hold the nose section of the missile to the main body of the missile housing. By turning a set screw it is possible to adjust the sound pitch from low to medium to high.

One significant feature is that with oscillation there is little drain on the battery. In both laboratory and field tests the first few manufactured missiles gave a strong oscillating signal for 8 hours without a stop. In another unusual instance, in the spring of 1957, three of these missiles gave an oscillated sound for 21 hours without a stop while being used to coordinate three separate ground search crews that were looking for a lost fisherman. Tests also determined that cold winter storage had no ill effect on the dry batteries.

The missile is waterproof, and will withstand the shock of hitting rocks, ledges, and other hard objects and still emit a strong signal. Experiments are now being made to devise a hard

rubber nose for the removable nose section to help break the shock of hitting hard objects.

The missile can be manually thrown from a plane "free fall" or with a parachute. Tests indicate it is best to use the parachute because there is no guarantee on "free fall" (fig. 2). The Maine Forest Service has devised for each of its two float planes a single V-shaped trough 10 feet long of aluminum tubing attached to the pontoon (fig. 3). The trough is of a size to permit carrying one or more missiles. Highly successful test drops have been made with this type of rack. Plans are underway to equip each plane with two racks to go on each pontoon. These racks can be easily attached or detached.

The present missile has an outside plug that has to be pulled or released in some manner to trigger the sound mechanism. When the missile is dropped by parachute the pulled plug stays with the static line in the plane. To the parachute case is attached an extra plug with which the person finding the missile can stop the sound signal. Otherwise, it would be necessary to remove the nose section and disconnect the battery wires.

With no actual lightning fires to make drops on, several experiments were made under typical woods conditions in Maine, New Hampshire, and the Provinces of Ontario and New Brunswick during the 1957 fire season. One test drop was made from the Maine Forest Service Cessna 170 float plane with very satisfactory results. By prearrangement a crew of ten was placed in an area with a $\frac{1}{2}$ -mile radius in a dense, second-growth hardwood type near a heavy white pine cutting. The missile, with sound signal working, was dropped from the plane at 2:05 p. m. at an altitude of 300 feet. At 2:25 p. m. the unit was discovered hanging about 5 feet above the ground with the 17-foot orange parachute caught on a branch of a hardwood tree (fig. 4).



FIGURE 2.—*Left*, Multiple chute release from plane of fire tools and locator missile. *Right*, Locator missile and pack of hose in descent.



FIGURE 3.—Sound locator missile in position in aluminum carrying rack attached to pontoon for air drops.

The following advantages brought out by experimental drops to date indicate that this sound locator missile has a practical and valuable use in forest fire control work:

1. The audible sound signal is effective at half mile distances and can be heard a mile away under favorable terrain and forest growth conditions.

2. The search area is greatly narrowed down.

3. The device permits quicker discovery of the fire at a saving of valuable time and cost.

4. The device permits early initial suppression action to prevent possible spread of fire.

5. Missile can be recovered and used repeatedly.

6. It is lightweight and can be easily transported.

7. It is compact, with a removable nose section to permit servicing.

8. Strong sound signals will emit continuously for at least 8 hours.

9. It can withstand the shock of hitting hard objects such as rocks, ledges, or trees, and still emit good sound signals.



FIGURE 4.—Parachute and missile found just as they landed in second-growth hardwood.

10. It is waterproof.

11. Missile can be released from the plane either manually or electrically "free fall" or by parachute.

12. Ground crews find the sound signal helpful while the missile is in descent, especially when coming down by parachute.

13. In open forest types the bright red missile and orange parachute can be easily seen, as well as the sound signal being heard.

14. Missile may have practical value for guiding rescue crews to lost persons and other uses not yet determined.

The Maine Forest Service has purchased six of these missiles and distributed two to a division. Several orders have been placed by protective agencies, while others have expressed an interest. Prints and further information may be obtained by writing to Maine Forest Service, State Office Building, Augusta, Me., attention Austin H. Wilkins.

BUILDING FIRELINE WITH A SELF-PROPELLED TRAIL GRADER

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In recent years, a self-propelled, two-man trail grader has been undergoing test in Region 6. This versatile machine is used not only to build new trails and improve old ones but to build fireline as well. Forty of these machines are in use in the region.

As with any new machine, improvements are continually being made. Three models are now in use. The original grader has a single 14-inch driving wheel; the second model has three wheels on one axle for additional traction; the third model has a crawler track 32½ inches long and 5 inches wide (fig. 1).



FIGURE 1.—The crawler-type trail grader. This model is best for fireline construction.

In order to obtain maximum performance of the grader in building fireline, the operators must be well trained. The machine is not a particularly easy one to operate, and there should be frequent reliefs, at least at half-hour intervals. Since the grader is a digging machine only, clearing must be done in advance. For these reasons the grader should be considered a crew machine.

FIRELINE-CONSTRUCTION TESTS

Test runs of single and three-wheel models were organized and reported by District Assistant W. M. Starkovich of the Ellensburg District of the Wenatchee National Forest. Organization of the 13-man crew was as follows: Crew foreman; 1 assistant foreman to locate line; 5 pulaski men to clear and chop; 1 power-saw operator to cut logs and large poles; 2 machine operators for trail grader; 1 man to carry extra gasoline and accessories and assist machine operators; 1 pulaski man to take out roots and decayed logs; 1 shovel man to finish line.

The following rates of line construction were recorded:

Moderate resistance to control type.—Mixed species of large Douglas-fir and western larch with dense stand of white fir understory. Medium amount of down logs with sizes up to 3 feet, and other litter and duff up to 6 inches in depth. Slope, 0 to 35 percent; rate of line construction, 36 chains per hour.

Low resistance to control type.—Pine with understory of pole-size Douglas-fir thickets, sodded pine grass, with light litter on the ground. Duff 2 to 3 inches deep. Slope, 0 to 40 percent; rate of line construction 43 chains per hour.

Large open ponderosa stand with very little litter on ground. Fairly heavy sodded pine grass. Slope, 0 to 45 percent; rate of line construction, 49 chains per hour.

In sidehill operation, the three-wheel machine tends to kick sideways and is difficult to hold in position. The one-wheel machine performs satisfactorily, but there is a noticeable lack of traction and a tendency for the driving wheel to dig in. The traction problem has been solved by using a crawler track instead of wheels. With this improvement, the machine has dug fireline up and down and on contour on a 70-percent slope. Twelve of the Region 6 machines have been converted to the track type.

PERFORMANCE ON FIRES

Opportunity to use the grader on fires has been limited. However, three track-type graders were used on a fire on the Wenatchee Forest in July. The fire started from a railroad on a steep, dry slope at midday. It had all the prospects of a project fire. Actually, credit for control at 60 acres goes to aerial tankers that knocked the fire out of the crowns of reproduction and fire-proofed a wide area on the running front, thus giving railroad workers a chance to move in with a handline.

The line built by the first two graders on the fire, which arrived before experienced fire overhead, was not properly located to be most effective. The third machine went all the way around the fire with a new line, some of which became the final line. In evaluating use of the machines, Ranger McNeil made it clear that he was not depreciating the machines in any way. The fact that there were 75 railroad workers on the fire with handtools made the machines less of a necessity than would otherwise have been true.



FIGURE 2.—Line constructed by the track-type grader on a side slope.

The grader builds an excellent fireline (fig. 2). Since the cutter disk is reversible, the dirt can be cast to either side. On cross-slope operation the dirt is cast downhill; otherwise, it is cast to the side away from the fire where it helps to insulate the fuel next to the line. The cutter disk will kick out rocks as large as coconuts, and is sturdy enough to withstand contact with larger rocks without damage. Brush-type roots are easily severed.

In summing up, the following points are made:

1. For trail construction, there is a difference of opinion as to the need for the crawler track. For fireline construction, there is no difference of opinion; the track is the answer.

2. This is definitely a crew machine. The size of the crew will vary with the fuel type. In areas where clearing is unnecessary, four men may be sufficient. Training in machine operation is required.

3. The machine can be transported in a pickup. The Wenatchee Forest carries its machine in a horse trailer.

4. The machine does not have a reverse, which is certainly desirable. The manufacturer is presently working on this problem.

5. Fire trenchers, at least in the Western States, should have a means of winching the machines through or across otherwise impassable areas such as sharp canyons and talus slides, or over ground where traction is difficult. A simple spool-type arrangement and 100 feet of nylon line should solve this problem.

6. It is much easier to work the machine down slope than it is up slope, and this fact is worthy of consideration in planning fireline construction.

SPECIFICATIONS FOR THE LATEST MODEL

Engine.—Nine hp., 4 cycles.

Transmission.—Transmission case, idler shaft, wheel shaft, and belt-tension adjustment idlers have sealed ball bearings—keywayed sprockets.

Clutching.—One master clutch from engine to jack shaft, controlled from lever on handle bars. Two secondary clutches that allow forward motion independent of rotation of cutter disk. Low speed (or work speed) allows travel up to $1\frac{1}{4}$ m. p. h. Secondary clutch lever allows for higher speeds up to 5 m. p. h. "Double clutch" arms and levers permit change of speed without stopping to change belts.

Gear box.—Shift on gear box for clockwise and counter-clockwise rotation of cutter disk. Removable disk, 16-, 18-, and 20-inch. Gear box adjustable to operate at four angles in relation to ground surface.

Brake.—Mechanical brake controlled by lever on right rear handle bar.

Front handles.—Adjustable up and down. Fold back for easier transport of machine.

Dimensions:

Height, 37 inches to handle bars, 24 inches to top of bed.

Length, 109 inches overall, front handles extended; 78 inches at top of bed, front handles folded; 50 inches at bottom of bed.

Width, 29 inches at handle bars, 17 inches at bottom of bed, 21 inches at bed top.

Weights, 1-wheel grader, 390 pounds; 3-wheel grader, 420 pounds; grader with track, 480 pounds.

GLARE-REDUCING GLASS FOR LOOKOUT STRUCTURES

DIVISION OF FIRE CONTROL
Region 7, U. S. Forest Service

Lookout personnel in modern towers are exposed to intense glare of light, and frequently to heat. As a result they experience eye discomfort that can be assumed to impair efficiency in searching for and locating smokes. Sunlight fades furniture, interior paint, and exposed maps, thus creating some maintenance problems.

The problem of glare from ordinary clear window glass has been worked on unsuccessfully. At one time towers were equipped with wooden shutters hinged at the top of the window to form a canopy over the window. This was abandoned in many localities because storms would tear them from the hinges and create a severe safety hazard. The use of sunglasses by towermen will help but sunglasses become tiresome and are often laid aside.

In 1955 the Region entered into a cooperative agreement with a firm which manufactures a glare-reducing glass. According to the manufacturer the glass gives an even transmission through the visible range of the spectrum. Colors are rendered without distortion but are greyed or toned in brilliance. The glass transmits but 65 percent of the heat energy in comparison with 86 percent by clear glass. According to the company the glass also transmits a large percent of the near ultraviolet light which is beneficial. This type of glass is used in modern schoolhouse construction.

This glass was installed by the company on the 14 x 14 cab of a 60-foot tower, located on top of the Alleghany Mountains, elevation 4,300 feet, on the George Washington National Forest. The comments made on its effectiveness are based on three fire seasons of use.

The color of objects is retained in true relationship although darkened. Glare is reduced to an extent that it is no longer evident. The glass acts as a haze cutter to improve visibility to a marked degree. Heat is reduced materially. The interior of the tower is protected from fading by the effects of bright sunlight. The critical test of any glass reducing light transmission is its effect on discovering night fires. It was determined that visibility was reduced to a minor degree only and that this reduction was not an important factor overall.

On a cloudy day more heat is required to keep the tower at a comfortable temperature than with clear glass as might be expected because of low heat transmission characteristics of the glass. The glass must be cleaned frequently because dust lowers

visibility perceptibly, much more than with clear glass. From the exterior this glass looks opaque with practically no "see in" properties.

As a result of the demonstrated advantages of this glass the forest is making a second installation. Its cost is about double that of clear glass, or approximately \$150.

A second lookout in the Region is equipped with a rose-tinted glass on the south and west sides. This has proved to be an aid in reducing glare and has haze-cutting properties. Its cost is also about double that of clear glass.

As a result of the tests conducted in the Region with glare-reducing, haze-cutting glass it can be stated that the advantages are material and the disadvantages small. The small investment is justified when compared with the added comfort and efficiency afforded the lookout.



Outdoor Fire Statistic Sign

The Arcadia Dispatcher's Office of the Angeles National Forest felt a need for some means of informing the public of the current fire situation. To meet this need a routed redwood sign with slots for removable figures was placed where both the general public and the nonfire personnel at the Arcadia Depot would notice it. The sign shows the fire danger for the day, total number of statistical fires to date, and acreage burned. It measures 24 by 50 inches, with 2- and 3-inch letters sprinkled with glass beads for night illumination.



This sign reaches many more people than an inside fire danger clock. Local comment has been very favorable, and some of the district rangers have expressed interest in using a similar sign at their headquarters.—CHARLES G. COLVER, *Assistant Dispatcher, Angeles National Forest.*

HOUSE TRAILERS FOR DETECTION OF FOREST FIRES

E. C. DEGRAAF

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In the Pacific Northwest an important forest fire control problem, not solved by the conventional lookout system, is the need for additional intensive detection over areas and drainages recently logged. Everyone is familiar with the fixed lookout stations used by the U. S. Forest Service and other forest protective agencies. Location, coverage, and intervening distance standards for these fixed lookouts were largely adapted to the protection of undeveloped areas. Detection standards were used that provided for coverage of large unbroken blocks of standing timber. The hazards and risks common to this condition were recognized, and protection was planned accordingly.

The situation in parts of the Northwest has changed appreciably. Logging roads are now opening up many timbered areas. Logging operations are expanding in all directions, and many unbroken timbered areas have now become a checkerboard of cutovers and logging slash. Logging no longer is limited to lower elevations, since heavy construction equipment, powerful logging trucks, and cable-type logging have pushed operations to whatever elevations contain stands of merchantable timber. This expansion in logging operations has provided access to many ridges and low mountain tops that offer excellent intensive detection coverage of the slash and timbered areas. If the slash on the logged units is burned successfully, it still represents a major change in fuel type and a somewhat hazardous area for a few years until the next crop is well established.

This change in hazard, from inaccessible areas of unbroken timber to accessible areas of highly flammable fuel types, calls for supplementing the fire detection program.

A ready answer to the problem is the use of a lightweight house trailer for mobile detection quarters. The house trailer should be relatively small with an abundance of windows. It should be light enough to be readily pulled up steep pitches by a $\frac{3}{4}$ -ton or 1-ton vehicle to the desired location. It should be short enough to negotiate sharp road curves. A firefinder does not have to be installed in the trailer; it can easily be installed on a fixed table or stump on the selected site to permit an unobstructed view of the surrounding country. It would need to be properly oriented and its position spotted on the platting map of the dispatcher. A waterproof plastic or canvas hood is all that is needed to cover the firefinder when it is not in use. A radio in the trailer provides necessary communications.

On the Olympic National Forest in northwestern Washington, logging operations and resulting conditions brought on the need for intensive detection of the cutover areas. The use of house trailers to provide mobile detection facilities was decided on and locations selected. Two trailers were placed strategically in the Forks Burn of the Soleduck District. This burn of 35,000 acres occurred in 1951 and has since been completely salvage logged. This resulted in a major slash area of mixed ownerships where further slash burning was not advisable. The nature of the terrain and the need for intensive detection are evident in figure 1, which shows some of the area blind to fixed lookout stations.



FIGURE 1.—Area seen from house trailer used for intensive detection on Burma Point in the Forks Burn. This broken terrain is not covered by direct visibility from fixed lookouts.

In the spring of 1956, a fire that could not be seen by the fixed lookouts was detected from one of the house trailer points in the Forks Burn.

A house trailer in 1956 cost \$2,178 delivered to the Shelton Ranger District. Transporting it into position on the Canyon River drainage cost an additional \$25. By comparison, the cost of a standard 14 x 14 ground lookout house constructed in place is from \$4,000 up (\$2,400 f. o. b. Portland). Compactness of the trailer and size of the conventional windows can be seen in figure 2.

After two fire seasons the merit of house trailers for detection in high-hazard areas has been established for conditions on the Olympic National Forest. To date, four house trailers have been purchased for this purpose. Two additional sites where this type of detection unit will be of value in logged-over areas are already selected for the 1957 season.

On the basis of experience on the Olympic National Forest, the use of a house trailer, with modified design if possible, offers



FIGURE 2.—House trailer on Burma Point in the Forks Burn. Opportunity is evident for increasing the size and number of windows for better vision.

an excellent means of supplementing fixed detection over logged areas with highly hazardous fuel types. This could become an effective and relatively low-cost method of insuring economical and flexible detection in one phase of fire control work in the Northwest.



Fire Hazard Data Available At Brooklyn Public Library

"To save even one life or prevent one injury to a civilian or fireman" was the aim of Fire Lt. Martin Chayette, a fireman in Brooklyn since 1945. Lt. Chayette was recovering from injuries received in battling a fire when the idea of collecting literature on fire hazards occurred to him.

Although he knew that the field of fire prevention and protection was vast, he also knew that there was no place where this information had been assembled. With this as a goal, he sought to establish a center where firemen, architects, businessmen, laymen, and students could find source material for further study. Deciding to create this source, he sent out more than 1,500 letters requesting available literature from fire underwriters, fire departments, insurance companies, and equipment manufacturers.

Pamphlets, bulletins, magazines, and books have been collected. Lt. Chayette has assembled more than 4,000 publications on fire hazards covering the field from acetylene and air conditioning to wiring and woodwork. The collection fills a dozen shelves and eight filing cabinets in the Science and Industry Division of the Brooklyn Public Library.

Lt. Chayette speaks with high praise of the cooperation given him by the Brooklyn Public Library. Plans for the future are progressing. The library allotted \$500 of its current budget to expand the collection. Eventually, it is hoped that the material on fire protection and prevention will be operated as a section of the library.—From an article in the New York World-Telegram and Sun, April 23, 1957.

FIRE TRAILER FOR A TREE FARM

JUDSON PARSONS

Mountcrest Tree Farm, Siskiyou Summit, Oregon

For our 1,800-acre tree farm in southern Oregon we constructed a small trailer (fig. 1) which can be pulled by a jeep, over our many roads, to any area on the tree farm.



FIGURE 1.—Trailer and equipment. The trailer, drum, and box are painted red with white "FIRE" signs on the sides and ends.

On the rear half of the trailer is mounted a 55-gallon drum with two valves connected to the lower bung-hole. Next to the drum is a hand-operated pump with 10 feet of suction hose. Water is pumped into the drum through the bung-hole on the upper side. The pump will fill the drum from a small pond in $2\frac{1}{2}$ minutes.

On the front of the trailer is a box in which fire tools are stored. The box is kept sealed, but not locked. The tools include two back-pack cans each containing 5 gallons of water, two shovels, two fire hoes, one ax, one bucket, and 75 feet of $\frac{1}{2}$ -inch garden hose with a trombone type pump similar to those on the back-pack cans.

The water in the drum can be used to refill the back-pack cans or with the garden hose and pump to pump water directly to the fire when the trailer can be brought within 75 feet of the fire.

We believe that this trailer and its equipment could control a small fire, or be used to advantage in helping to control a large fire. Also, the trailer, with its red color and white letters, is a constant reminder to those on the tree farm of the everpresent fire danger.

MOPUP KITS FOR REGION 6

A. B. EVERTS

*Equipment Engineer, Division of Fire Control, Region 6,
U. S. Forest Service*

Even though water is a great aid in quick and efficient mop-up, great quantities may not have to be used; small amounts properly applied will do the job. The technique of "proper application" is to put water where it will do the most good. Region 6, as a third step in its efforts to secure more efficient use of water in fire control, particularly in mopup, has assembled a standard mopup kit.

The first step was to standardize on tank-truck and portable-pumper accessories.¹ The second step was to supplement pumping equipment with various items such as 1000-gallon folding canvas tanks, relay tanks, gravity intakes, and the pyramidal tanks whose use can make "nurse" tankers out of any flat bed vehicle. These items, along with small slipon tankers and portable pumps, provide the means of getting water to fires.² The third step was the assembling in one kit box those accessories needed for applying water efficiently over a wide area (fig. 1).



FIGURE 1.—Region 6 standard mopup kit.

¹A. B. Everts. *Versatility in Water Application*. U. S. Forest Serv. Fire Control Notes 15 (2): 30-34, illus. 1954.

²A. B. Everts. *Canvas Water Show*. U. S. Forest Serv. Fire Control Notes 17 (2): 12-15, illus. 1956.

The contents of a mopup kit are as follows:

	<i>Number</i>
Applicators, 4-foot aluminum.....	6
Packsacks	2
Spray tips, 15 g. p. m.....	2
Straight stream tips, ¼-inch.....	2
Garden hose Y's.....	4
Hose tees (1½-inch with 1-inch takeoffs with caps).....	6
Reducers (1½ to 1-inch).....	2
Spanner wrenches	2
Nozzle pouches (red canvas for easy visibility), each containing a 3 g. p. m. spray tip (¾-inch garden hose threads), a reducer (1 to ¾-inch garden), and a sleeve-type shutoff (with an assortment of 1½-, 1-, and ¾-inch washers).....	6

This equipment permits the use of six lateral takeoffs from a 1½-inch main line, using either 1-inch CJRL hose or garden hose or both. If the water source is from tankers where the conservation of water is a factor, the sleeve-type shutoff is used on the applicator; otherwise, it is not used.

Nozzlemen should work in pairs, one man digging, stirring, and rolling out burning material, and the other applying the water (fig. 2). The applicator permits the ramming of the spray tip into the smoldering material. For conservative use of water the 3 g. p. m. spray tip is sufficient. It is the favorite tip in the region.



FIGURE 2.—Four-foot aluminum applicator with 15 g. p. m. spray tip.

A foreman should be in overall charge of each mopup sector. It is his job to determine where the takeoffs are to be placed in 1½-inch main lines and how far out lateral lines are to extend, to check on the thoroughness of the mopup crews, and to see that all the items are returned to the kit box when the job is done.

The cost of the entire kit, including box, is approximately \$200.

RECORDS AND EXPERIENCE OF DISCOVERING FIRES FROM AIRCRAFT

WILLIAM G. MORRIS

Forester, Fire Research, Pacific Northwest Forest and Range Experiment Station

During the period 1950-56 about 250 fires on four national forests of Oregon and Washington were discovered by searchers in airplanes; 93 percent were only small spots when discovered.

To learn some of the circumstances of fire discovery from aircraft, the four national forests that were the most frequent users of aerial patrol were selected for study. The personnel kept special records concerning fires discovered and fires missed by aerial patrol, method of using the eyes while looking for fires, and conditions that might affect efficiency of an aerial observer. Of the 247 reports on fires first discovered by aerial observers, Wallowa-Whitman National Forest submitted 134, Okanogan 89, Mt. Baker 13, and Siskiyou 11.

Distribution of these fires according to size when discovered was as follows: (1) Spots too small to warrant an estimate in terms of a fraction of an acre—93 percent; (2) larger than the foregoing but not more than one-quarter acre—4 percent; (3) more than one-quarter acre—3 percent.

Lightning caused 96 percent of the fires and the remainder were man caused.

Discovery time—elapsed time from origin to discovery—was 3 days or more for 9 percent of the fires, and, as commonly happens with sleeper lightning fires, a few were discovered after 3 weeks. For those discovered in less than 3 days, the average time was 15 hours. Fires that were larger than one-quarter acre when discovered had, on the average, longer discovery times than the smaller fires. A fairly long average discovery time by aerial observers can be expected on these national forests. As shown above, most fires were caused by lightning. Since a large proportion of lightning occurs late in the afternoon or after dark, clouds and darkness usually prevent aerial search before the following morning.

Distance from observer to fire at time of discovery was recorded for 105 fires, and the average was 1.3 miles.

Most aerial discoveries—85 percent—were made during the first flight near the fire after ignition, while 10 percent were made during the second flight and 5 percent during later flights.

The forests reported 34 fires missed by aircraft searchers and later discovered by other kinds of detection. Average distance at which the flight passed the fire was 2.3 miles, and only

3 fires were in areas invisible to the aerial observers. These fires were very small at the time they were missed by aerial observers. Two-thirds were still only small spots when later discovered. Lightning fires often smolder several days¹ or even weeks before producing enough heat and smoke to be visible above the forest canopy. Many of the missed fires may have been this type.

In several years, reports were submitted giving the proportion of reportable and miscellaneous smokes first seen by quick scanning compared to slow and careful looking. By far the greater proportion were first seen while quickly scanning. As shown by supplementary memoranda by observers, some were found only after repeated circling and painstaking scrutiny of the general location where the observer knew a smoke had been previously seen. These were the thin small smokes that reflect little light and would probably be missed by quick scanning. Some observers stated they usually used a quick scanning method, but others usually used a slow and careful looking method. Some gave the visible area a preliminary quick scanning to detect clearly visible smokes and followed this with slower, systematic searching as time permitted. This method probably makes the best use of available time in completely covering the visible area and searching for poorly visible smokes.

In two years the observers were asked to determine whether length of flying time, rough air, or airplane noise and vibration affected their alertness in seeing the frequent nonreportable small white smokes, such as those from certain chimneys, mills, and permitted bonfires. They were equally divided in opinion as to whether long flying time decreased their detection efficiency. Most thought neither rough air nor noise and vibration were important factors.

The foregoing records of experience in aerial detection of fires on four widely separated national forests of Oregon and Washington should be useful when considering use of this detection system, estimating its reliability, and training aerial observers.

¹MORRIS, WILLIAM G. *Lightning Fire Discovery Time on National Forests in Oregon and Washington*. Fire Control Notes 9 (4): 1-5. 1948.

SIUSLAW FIELD HOSE WASHER

ARVID C. ELLSON, *Forester*, and ALBERT B. SHROY,
District Assistant, Siuslaw National Forest

The Siuslaw National Forest has a large and complex slash disposal problem. After a unit has been burned, mopup starts immediately. Water is used extensively. The hose used becomes caked with mud and ashes. The Siuslaw washer was devised for washing hose on the job as it is gathered in from the line.

The washer, made in a local shop at a cost of \$13.65, consists of a stem and ring of 1-inch water or boiler pipe, two guide rings to keep hose centered, and a C-clamp for mounting the washer in any convenient place (fig. 1). Eighteen 1/16-inch holes are drilled in the pipe ring. Water is pumped into the washer under pressures of from 100 to 200 pounds.



FIGURE 1.—Siuslaw field hose washer; in use clamped to tailgate of pickup.

At 100 pounds pressure the water use is approximately 21 g. p. m. At 200 pounds it is 30.7 g. p. m. These deliveries are well within the capabilities of the pumps used in Region 6.

SCOOTERS FOR TRAIL TRAVEL¹

*Compiled by Equipment Development Section
Region 1, U. S. Forest Service*

A few years ago, leisurely foot or horse travel over scenic forest trails was considered by many as a part of the reward of forestry work. Foresters in general have not changed in this appreciation, but the steadily increasing cost of nonproductive trail travel is of considerable concern.

During the past 10 years, administrators have given serious thought to the possibilities of modified commercial scooters and other machines for use on selected trails. Experimental use has been attempted in various regions with not too promising results. Region 1 has been building, testing, and conducting a limited operational use program since 1945. Slow field acceptance has been due largely to an almost total lack of up-to-standard trails or to below-standard sections in the trail which are bottlenecks to scooter travel.

The comparatively recent program to mechanize trail maintenance, a cooperative effort of Regions 1, 4, 5, and 6, clearly demonstrates the need and the possibilities for faster and easier trail travel. Through this program, the development of scooters has been accelerated and present designs are proving highly successful in operational tests.

TRAIL SCOOTER DEVELOPMENT

Early commercial scooters tried on forest trails were underpowered for the steep grades and rough trail treads encountered. In 1946, a commercially made scooter was modified to obtain increased performance. This machine was powered by a 5-hp., 2-cycle engine. It incorporated a fluid coupling that eliminated the usual clutch and provided torque for holding the machine on steep grades by advancing the throttle. Other modified scooters were also tested to determine necessary performance requirements. The Forest Service completely designed and constructed a scooter for the first time (fig. 1).

A 1948 Forest Service model, built for testing over selected trails, provided loading space for equipment at the lowest possible position on the frame. Weight was again reduced slightly and performance increased. This machine is in current use and has worn out two sets of rear tires in trail travel.

In 1952, a "powered wheel" was constructed to test the balance and advantages of a large-diameter tire (fig. 2). With a trailing, stand-on platform, it became a slow-speed scooter. Although not successful, it was the first in a series of the stand-on type.

In 1954, a test scooter using the stand-on principle was constructed (fig. 3). The 2½-hp. motor provided power for 30- to

¹This is a slightly shortened version of *Scooters for Trail Travel*, U. S. Dept. Agr. Forest Serv. Equip. Devlpmt. Rpt. 46, 10 pp., illus. 1957. [Processed.]



FIGURE 1.—This Forest Service 1947 model used a 6-hp., 4-cycle engine, with a fluid coupling incorporated in the drive arrangement. Weight was reduced by the liberal use of aluminum angles and tubing.

35-percent grades and a top speed of about 12 m. p. h. Where trail treads or grades did not permit safe riding, the handle over the gasoline tank actuated the clutch and provided power for “walking” the machine. With the operator in standing position, he needed only to step to the ground when trouble developed. Where treads were narrow and dangerous, one foot could be used in a manner similar to that of a boy riding a sidewalk scooter.

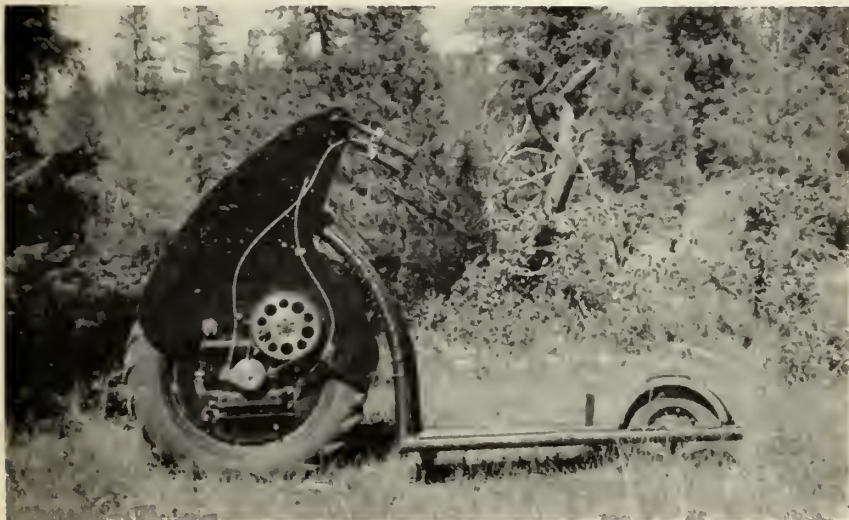


FIGURE 2.—“Powered wheel” with stand-on platform.



FIGURE 3.—This pilot model weighed only 126 pounds and could easily be manhandled at creek crossings and slides, or over logs. It could be folded for transportation in a passenger car.

A standard commercial model, modified in 1954 for trail travel, has adequate performance for any trail improved to a reasonable scooter standard. Initial cost, including modifications, is approximately \$500. Space for hauling heavy loads or maintenance tools has been provided.

An improved model of the 1954 stand-on machine was built for field testing, and the next year performance was further improved and our experience broadened. Weight of the 1955 model was 135 pounds.

Another commercial model was modified for operational testing during the 1955 season, and a second machine, with modifications listed below, was used during 1956 (fig. 4). Riders state that the tank, located between the legs, gives better balance and control. They believe the advantages of this arrangement offset any reduction in safety compared with the open frame of the standard model. Considering that these heavy commercial machines are intended primarily for use on trails improved to at least scooter standards, any reduction in safety may be insignificant.

Modifications on this machine include the following:

1. Maximum possible reduction through enlarging the final driven sprocket and reducing to a minimum size the final driving sprocket.
2. Increase clearance of frame approximately 3 inches front and rear.
3. Remove footrests and modify frame so both feet are placed inside the frame for protection.
4. Rearrange brake and clutch controls so brake may be applied with either foot, and clutch is engaged by use of throttle only.
5. Rearrange carrier rack to accommodate greater load at minimum height.
6. Attach a smooth skid-pan to underside of frame to protect machine in rocky areas.

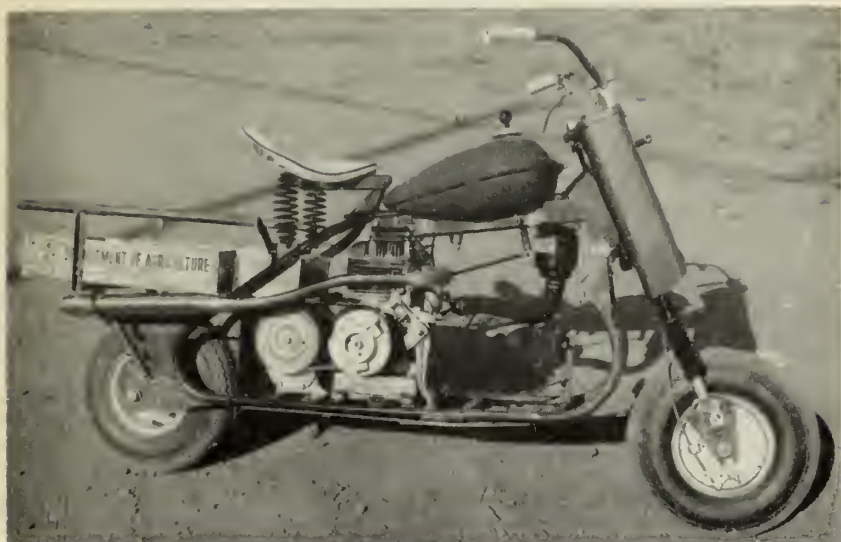


FIGURE 4.—The 1956 model has proved to be a nimble performer, and field forces in Region 1 prefer this machine for heavy hauling and travel over mechanized trails.

The 1956 model Forest Service stand-on scooter (fig. 5) incorporates several new features for observation and operational testing: (1) low-pressure air wheels without inner tubes used with special hubs that grip the tire bead to prevent any possibility of turning on the hub—a problem with conventional tires; (2) load space in front of operator for light loads such as



FIGURE 5.—This model has exceptional climb performance due to the increased traction. The low-pressure air wheels have also contributed materially to the clinging ability on sloping trail treads, and to a softer ride on rough trails. It is somewhat harder to steer and possibly slightly harder to balance than the previous models with smaller tires.

sleeping bag, personal gear, chain saw for "logging out," etc.; (3) simplified clutch and speed-change arrangement; (4) hydraulic front and rear brakes. Other features developed and tested in two previous models were generally maintained.

Our several years of exploratory and development work lead us to believe that there will be a need for two general types of trail scooters. The stand-on model offers maximum performance and safety for use on substandard trails. The cost advantage (commercial stand-on machines are estimated to cost less than \$250) will permit a larger number for light maintenance work and administrative travel.

The standard and special commercial models, modified for improved safety and better trail performance, will be used on trails maintained to scooter standards. They are generally more comfortable to ride and can carry a substantial load in addition to the rider. If used on improved trails, where manhandling is not necessary, the heavy overall weight is not particularly objectionable.

A trail maintenance unit has been developed for scooter transport which permits one or two nights away from roads and stations. This usually provides sufficient time for maintenance men, riding scooters, to complete a continuous section without backtracking. Present plans in Region 1 contemplate mechanization for selected trails only. Their mileage is estimated to be about 50 percent of the total trail system or approximately 14,000 miles. The program will require 10 or 12 years with presently available financing.

CONTINUING DEVELOPMENT

We anticipate continued improvement in operational use, dependability, and handling characteristics over the next few years. Although no major programs are contemplated, a limited development program should be continued.

A design for commercial production of a stand-on machine for operational testing during the summer of 1957 had these important specifications:

1. Total empty weight not to exceed 135 pounds.
2. Air-cooled, single-cylinder motor of 3 to 4 hp.
3. Air-wheel tire in rear, 8:00 x 4 or larger. Front tire not less than 5:00 x 6 and may be normal pressure.
4. Usable trail speed 2 to 12 m. p. h. by means of variable-speed belt transmission with automatic clutch.
5. Dual wheel brakes; rear brake may be on jackshaft. Applied by hand pressure.
6. Arranged for "stand-on" operation.

Our experience has proved the stand-on principle for rough or dangerous trail use. There is a good possibility that the motor could be located immediately behind the front wheel to increase the torque leverage. (Present machines are limited in absolute climb by the tendency to "rear up" in front on 45-percent-plus grades, due to the considerable torque requirements and the exceptional tractive ability of the air wheel.) A seat could be provided (it probably would be desirable in some situations) that

would swing back when the operator stood up or when he wished to "pedal" the machine with one foot for safety. All controls should be arranged on the handle bars to enable the operator to control the machine while walking alongside.

We have made arrangements to obtain a prototype air wheel, 16 inches in diameter, 12 inches in width, and with a 4-inch hub. This soft tire, which utilizes the "rollagon" principle, may be entirely suited to the stand-on scooter. A test program now under way will determine the possibilities.

Although the modified commercial scooters now available have proved very successful in operational use on improved trails, some development investigation should be continued. Early heavy-duty Forest Service designs proved the value of a fluid coupling in the final drive. We believe that if this coupling could be incorporated in the modification of heavy-duty commercial machines, there would be a considerable improvement in safety performance and handling qualities.

SCOOTER REQUIREMENTS AND PERFORMANCE

Any system for rating development progress will provide room for argument. A rating system does, however, provide a tentative comparison between machines and stress items of performance that are believed to be most essential. It is doubtful if any present carrier (scooter or motorcycle) would be rated 100 points (table 1). All would have some deficiencies.

Safety. The ideal personnel carrier for narrow trails and off-road use must first of all be a safe machine when operated properly.

Rough trail travel ability permits greater utility and contributes to many other performance features.

Mechanical dependability is achieved through proper design, skillful workmanship and the correct use of proper materials. The proof is found by experience.

Effective speed range. A machine capable of 25 m. p. h. would be useless for rough trail travel. To obtain an effective range from 3 to 25 m. p. h. is extremely difficult. The three scooters compared here have an approximate effective range as follows: USFS stand-on, 2 to 12 m. p. h.; modified commercial model #1, 4 to 18 m. p. h.; modified commercial model #2, 6 to 25 m. p. h.

The type of intended use has considerable bearing on the speed selection. The stand-on, for example, is intended for very rough trails, therefore, a slower speed is necessary. With a sacrifice of top speed, we were able to utilize a small and light motor to climb very steep grades, and maintain minimum machine weight for ease in manhandling when necessary. The modified commercial models would have rough going in these areas since the operator would need to travel too fast for maximum safety in order to obtain necessary traction.

Ease of handling has been rated 10 points, maximum. It is possible that a machine might rate zero for ease of handling but have superior performance in all other respects.

TABLE 1.—*Scooter requirements, tentative rating, and comparison of performance*

Requirement	Maximum rating point	Forest Service stand-on	Modified commercial model #1	Modified commercial model #2
Safety of operation (controls, brakes, skill requirements, position)	20	18	15	13
Rough trail travel ability:				
Climb grades of 45 percent or more (average traction)	5	5	2	3
Descend grades of 45 percent or more (average traction)	5	4	2	3
Travel rough, rocky trails; stream crossing	5	4	4	4
Traverse sloping trail treads (sidehills)	5	5	2	3
Mechanical dependability	15	10	12	12
Effective speed range (3 to 25 m. p. h. trail and road travel)	15	10	13	13
Ease of handling:				
Easy to balance and steer (crooked, rough trails)	5	4	3	4
Easy to manhandle (turning, walking, loading, lifting, carrying)	5	5	1	2
Load capacity, 100-pound load plus rider	10	5	9	9
Economy of operation	5	4	3	3
Comfort of operations, riding (fatigue elements; quality of ride)	5	3	3	4
Total	100	77	69	73

Load capacity of 100 pounds in addition to the rider would certainly add to the utility of any carrier. The stand-on scooter is limited in its ability to carry equipment and supplies in excess of 30 or 40 pounds. It is, therefore, rated accordingly.

Economy of operation.—Exceptional performance could easily offset poor economy.

Comfort of operations.—The same argument applies to comfort as to economy of operation.

FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.



*Smokey
Says:*



**BE CAREFUL
WITH MATCHES
WITH SMOKES
WITH ANY FIRE**

Remember - only you can
PREVENT FOREST FIRES!

